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REPRODUCTION AND EARLY POST-NATAL DEVELOPMENT OF THE COTTON MOUSE, *PEROMYSCUS GOSSYPINUS GOSSYPINUS*

BY GEORGE H. POURNELLE

It is common knowledge that the success of any mammalian species is governed by the balance between its reproductive rate and the environmental resistance. The number of young per litter, number of litters produced in a given unit of time, as well as the rapidity of growth to sexual maturity, are factors of fundamental importance in determining whether the species will maintain itself successfully against the tremendous rigors of the environment. In recent years our knowledge concerning the reproductive habits of many native North American rodents has been added to materially by Svihla (1932), Clark (1936*a*, 1936*b*, 1938), Meyer and Meyer (1944), Hamilton (1941), and others. An excellent summary of this information is contained in Asdell (1946*a*).

The following report is the result of an investigation of the reproductive habits and early post-natal development of the cotton mouse, *Peromyscus gossypinus gossypinus* (LeConte), in North Florida. These rodents are among the most abundant mammals in southeastern United States. Their ecological importance as a control of small invertebrate populations is mentioned by Calhoun (1941: 214) who found, through analysis of stomach contents, that the food of the cotton mouse in Tennessee consisted of 68 per cent animal matter, chiefly arthropods of the groups Coleoptera, Lepidoptera, and Araneida.

While very little published data are available on the predator-prey relationships of the cotton mouse, it is very probable that this rodent is a basic food source for many predaceous forms throughout its range. Evidence of predation on this species by the blacksnake, *Coluber constrictor constrictor*, has been cited by Harper (1927: 345), while cotton mouse remains were recorded from the stomach of an Alabama rattlesnake by Howell (1921: 50). Among other important enemies may be listed, no doubt, the numerous raccoons, owls, cottonmouth moccasins, and various water snakes which haunt the deep hammocks and swamps that are favorite abodes of this species.

Despite the abundance and ecological importance of the cotton mouse, information concerning many phases of its life history is not available in the literature. Concerning the phenomena of reproduction and growth this is especially true, although a few references are available, usually in regional check lists or as incidental notes collected in the course of other studies.

The most extensive report is a discussion and summary of breeding data, based on females from the vicinity of Gainesville, Florida, by Barrington (1949: 51). Barrington's data indicate a decrease in breeding activities of the cotton mouse during the summer. He records pregnant females for all months of the year except June, July, August, and September. Juveniles were taken during all months except April, June, August, and September.

Records of two cotton mouse litters for the month of January, 1940, and two pregnant females for December, 1946, and February, 1947, respectively, from the east coast of Florida, are given by Ivey (1949: 160). In the same paper are cited records of juveniles taken in December and January. Ivey also gives the average testes length (17.3 mm) of three males taken in November and December.

Courting behavior of a captive male from Welaka, Florida, and a brief discussion of general breeding conditions based on observations of external genitalia of a limited number of mice from the same area are given by Moore (1942: 117, 124).

Four litters of cotton mice (presumably *P. g. palmarius*) from Hicoria in Highland County, Florida, are recorded by Rand and Host (1942: 19). One of these litters was born in September, one in October, and two in November.

About one-third of the specimens taken by Harper (1927: 345) during December and January in the Okefinokee Swamp were in immature pelage. Harper also mentions two adult females which were brought to his camp, together with three or four tiny young, during early June. The young were eaten by one or both females a few days after capture.

The fertility relations between *P. gossypinus* and *P. leucopus* are discussed by Dice (1940: 14). This author found that the two species hybridize and produce fertile offspring in the laboratory, but cited no evidence of hybridization under natural conditions.

It has been demonstrated that reproductive patterns in the genus *Peromyscus* vary considerably. For example, some mice of this genus experience an after parturition heat while others do not (Svihla, 1931: 10). The average age of first estrum of *P. polionotus* was found to be 29.64 days as contrasted with 48.72 days for *P. maniculatus* as demonstrated with laboratory specimens (Clark, 1938: 332). These mice are in the same species group, but have different geographic ranges.

There is no doubt that environmental factors have an influence on reproduction. Evidence presented later in this paper points to the effect of high temperature on the breeding condition of male cotton mice. It has also been shown that seasonal breeders adjust their breeding seasons to the appropriate time of the year when transferred across the equator (Asdell, 1946*b*: 3).

To the following people I extend my thanks for assistance rendered during the course of this study. Dr. H. B. Sherman, who first introduced me to the ways of mammals many years ago, has rendered invaluable aid both in preparation of this paper and in advice on details of the investigation. Dr. H. Ruffin Jones, Jr., has given useful suggestions on staining techniques. Dr. B. A. Bar-

rington, Jr., and Messrs. Paul Pearson, William Jennings, and Andrew Rogers have contributed specimens of cotton mice at various times. I am also indebted to Mr. William Dunsen, Superintendent of the University of Florida Conservation Reserve, for his co-operation during my stay, and to Mrs. G. H. Pournelle for assistance in the field and help in typing of the manuscript.

Finally, it gives me pleasure to acknowledge the assistance of many others who have lent their aid and companionship on collecting trips or have passed on information concerning various collecting locales which have yielded much data that might never have been obtained otherwise.

Work was made possible through a University of Florida Fellowship Grant for which I am deeply grateful.

Field studies were carried out in the vicinity of the University of Florida Conservation Reserve at Welaka, Florida, from September, 1947, until September, 1948. Following this period work was continued at Gainesville, Florida, through April, 1950. During the latter time periodic collections were made from Welaka.

The Welaka area, from which most of the mice were trapped, is located in Putnam County directly across the St. Johns River from its junction with the Ocklawaha River. The Gainesville area is in Alachua County, approximately forty miles northwest of Welaka.

Rogers (1933: 9) summarizes the climate of North Florida as being characterized by "... mild, relatively dry winters, and the long summers with a pronounced mid-summer rainy season." The average temperature of the Welaka area for the period from September, 1947, through April, 1950, was 71.4 degrees F. Average temperature for the summer months is about 80 degrees. Readings of 95 degrees or above were recorded in September, 1947, and in May, June, July, August, and September of 1948 and 1949. Below freezing temperatures were recorded in January of both years.

Total monthly precipitations of over five inches were recorded in September, 1947, July, August, and September of 1948, April, August, and September of 1949, and April, 1950. Less than one inch was recorded in March and May, 1949; and January and February of 1950. These data were obtained from the Crescent City weather station which is about twelve miles from Welaka.

Since the reserve is located just south of the 30th parallel, it receives very intense sunlight. During the middle of June the sun is nearly directly above at midday. The average number of clear days per year is 131, partly cloudy, 140, and cloudy, 94 (Laessle, 1942: 14).

METHODS AND MATERIALS

In all, 1153 cotton mice, including 888 field-trapped and 265 laboratory-reared animals were used in this study. Of the field-trapped animals, 506 (56.98 per cent) were males and 382 (43.02 per cent) were females. All were captured in Sherman live traps. A mixture of peanut butter and oatmeal was used for bait.

Although the cotton mouse has been taken in many types of plant communities, it shows a preference for moist, wooded areas. It was taken in greatest numbers in hydric hammocks where fallen logs and hollow trees were abundant. In such situations I have always found it to be the predominant form taken in small traps. This is illustrated by the following data concerning the numbers of individuals taken in 2777 trap-nights in this type of community:

Cotton mice, 357; rice rats, *Oryzomys palustris natator*, 12; golden mice, *Peromyscus nuttalli aureolus*, 7; short-tailed shrew, *Blarina brevicauda carolinensis*, 4; cotton rats, *Sigmodon hispidus hispidus*, 4. The cotton rats were probably chance visitors from nearby drier areas.

Extensive areas of uncleared river swamp occur along the St. Johns River in Putnam County. This swamp is broken in many places by elevations covered by hydric or mesic hammocks. These latter communities are not subject to periodic flooding and are usually thickly covered with logs, stumps, fallen palm fronds, and other debris, all of which form ideal nesting material. The fact that the hammocks are less subject to water fluctuations and, in addition, contain ample nesting sites may be responsible for the concentrated populations of cotton mice in these areas.

The 265 laboratory-reared animals represent seventy-two litters and were, for the most part, direct progeny of wild parents though a few were second generation captives.

Cages in which the cotton mice were kept were constructed of ¼-inch mesh hardware cloth with baking pans employed for tops and bottoms. These cages were 15½ inches long by 14½ inches wide by 12 inches high. Quart-size fruit jars containing cotton were placed in each cage for nests. Occasionally smaller jars were used and these proved quite satisfactory, though, on occasions, the cotton was pulled out and into a corner of the cage. Exercise wheels were also provided and sawdust was used as an absorbent. Food was supplied in the form of Frisky Dog Checkers and regular supplements of lettuce. Water was available at all times.

Pregnant females near term were usually transferred to an aquarium which was fitted with a hardware cloth top. This served as an ideal observation chamber and also as a temporary cage during the first months following birth.

Cotton mice in the laboratory are quite gregarious. When several mice were placed in a single cage, very little fighting took place. Regardless of the number of nesting bottles present in the cage, all of the animals would usually occupy the same one, even if the cotton had to be pulled out to make room. Often an overnight change was made by the whole group from one nest bottle to another.

Information concerning the natural breeding cycle of the cotton mouse was obtained by live trapping animals throughout the year. Captured females were kept in isolation until they gave birth to litters as a result of field matings or until a sufficient time had elapsed, usually about a week, for embryos, if present, to be of detectable size, upon dissection. I believe that the practice of determining pregnancy by external appearance and palpation is, except during very late stages, extremely unreliable. This method is sometimes used, however, chiefly by those who are dealing with marked animals in the field in which the desirability of accumulating data on live animals prohibits their being killed.

In addition to standard body measurements recorded for the mice, measurements of testes were taken to indicate breeding conditions of males. The presence or absence of live spermatozoa in the epididymis was determined by wet smears. These smears were made by crushing the epididymis of a freshly-killed mouse in a drop or two of Ringers solution on a microscope slide. Samples of testes of ninety-eight individuals were preserved for sectioning. This material was fixed in FAA for at least two days and cleared in toluene. The FAA was prepared as follows: 95 per cent ethyl alcohol, 10 parts; glacial acetic acid, 1 part; commercial formalin, 1 part; and distilled water, 8 parts.

All sections of the testes were cut at thicknesses of eight, nine, or ten microns and stained with iron haematoxylin. The procedure described by Cleveland (1949: 2) was used; a 10 per cent stock solution of haematoxylin was diluted to one per cent immediately before use. Sections were stained for thirty minutes and destained in a 1–2 per cent ferric alum solution.

In determining gestation periods the females were placed in a cage with one or more breeding males. Mating was evidenced by the presence of spermatozoa in the vaginal smear, and the female was isolated until parturition took place. Sometimes smears were not taken, in which case the female was simply left with the male over night and isolated the following morning. On occasion a male was allowed to remain with a pregnant female until shortly after parturition. This procedure was followed in order to gather data on the post-parturition heat period.

Pregnant females near term were placed in an aquarium to facilitate observation. A wrist watch with a sweep second hand was used to time details of parturitions. Data on litter sizes were collected from young mice at birth and from embryo counts of pregnant females. Details of development were compiled from records of daily observations.

Forty-five mice from fourteen litters were used in an investigation of growth rates. Body measurements were taken at ten-day intervals from the day of birth through the 60th day. The measurements taken on each mouse were: weight, total length, length of tail, and length of hind foot.

Beginning with the 35th day of age, representative sections of testes were made for the purpose of determining the age at which mature spermatozoa are present. Most of these sections were taken at five-day intervals and continued through the 72nd day. The age at which a mouse was considered to be sexually mature was determined by these sections and by the presence of motile spermatozoa in the epididymis. The foregoing data when correlated with growth rates were useful in deciding whether a wild-trapped animal should be considered an adult.

Vaginal smears taken three times daily furnished data concerning the estrous cycle. A pipette drawn to a fine point and rounded off to avoid irritation of the vaginal wall was used. In taking the samples, a few drops of Ringers solution were introduced gently into the vagina of the mouse and quickly drawn out. This material was then spread on a slide and fixed in a 95 per cent alcohol-ether mixture before drying. The slides were then stained with standard alum haematoxylin and triosin. Ovaries and oviducts of females showing different smear pictures were sectioned and examined in order to correlate the vaginal cycle with time of ovulation. These sections were cut at thirteen microns in thickness and stained with alum haematoxylin and triosin.

On one series of ten mice cotton swabs fashioned from rounded toothpicks were used to obtain samples of vaginal washings. Although these samples were taken only once a day and extreme care was used to avoid irritation, upset of the cycle was evidenced by a continuous cornified picture. Wade and Doisy (1935) demonstrated with the laboratory rat that the cotton swab method of obtaining samples will lead to a cornified smear indicating estrum in ovariectomized animals where this condition, of course, cannot occur. These authors found, however, that their animals did not show this condition unless smears were made as often as two or three times a day.

ESTROUS CYCLES

The vaginal cycle.—Cyclic changes of cell types in vaginal washings as a guide to condition of heat in rodents was first described by Stockard and Papanicolaou in work with the guinea pig (1917). Application of this method to the laboratory rat (Long and Evans, 1922) and house mouse (Allen, 1922) soon followed. Clark (1936*a*) described the estrous cycle of the deer mouse, *Peromyscus maniculatus bairdi*. His description of the four classic stages of the cycle as shown by vaginal smears may be summarized as follows. *Proestrum:* Characterized by a marked increase in nucleated epithelial cells and a reduction in number of leucocytes. Often there is a reduction of leucocytes and an increase in cornified cells with relatively few nucleated cells being present. Average duration is 20.7 hours. *Estrum:* Chiefly cornified cells present. Nucleated cells present in early and late stages. Average duration is 26.2 hours. *Metestrum:* Smear composed of dark staining nucleated epithelial cells which gradually decrease in number concurrently with an increase in leucocytes. Average duration is 20.3 hours. *Diestrum:* The smear is composed almost entirely of leucocytes. Average duration is 49.9 hours. *Average duration of complete cycle:* 4.8 days.

The vaginal smear picture of the cotton mouse is much like that described by Clark. The following points not mentioned by this author are applicable to my material: (1) An estrous smear composed entirely of cornified cells was not often found. A few nucleated cells were almost always present during the entire stage; occasionally there were a few leucocytes. (2) Metestrum was sometimes evidenced by a decrease in cornified cells with appearance and rapid increase in leucocytes, very few nucleated cells being involved.

Vaginal smears were taken on three groups of nine, five, and ten mice, respectively. Of

these three groups only the first gave information concerning the vaginal cycle. In the group of ten animals a continuous series of cornified smears was obtained after the first few samples. In only one case was there evidence of cellular fluctuations, and here the stages were so obscured as to be worthless for diagnostic purposes. This condition was attributed to irritation of the vaginal epithelium by use of cotton swabs as mentioned earlier.

In the second group smears were taken three times daily during the month of June by the pipette method. In the case of these animals an almost unbroken series of diestrous smears, made up predominantly of leucocytes, was obtained. Sampling was discontinued on this group after six days. This supports evidence presented later that the reproductive activities of the cotton mouse are at a low ebb during the summer months.

In the remaining group of mice, from which smears were obtained during the spring of 1948, the average length of thirteen complete cycles of six females was 5.26 days (3.5 to 10 days). Four cycles of one female averaged 4.35 days in length (3.5 to 5.7 days). Three of the cycles of the latter individual were below the average length found for the entire group.

The average length of the proestrous stage, based on eleven records, is 21.1 hours (8 to 30 hours). For the estrous stage, based on ten records, the average duration is 23.9 hours (12 to 36 hours). The average of eleven metestrous lengths was 29.5 hours (23 to 46 hours), while ten diestrous intervals averaged 49.5 hours (24 to 74 hours).

In comparing the above averages with Clark's data on the deer mouse, it can be seen that the lengths of proestrum and diestrum agree quite closely in these two species. The estrous stage of the deer mouse is somewhat longer than that of the cotton mouse, while the latter shows a markedly longer period of metestrum. The total length of the cycle averages longer in the case of the cotton mouse.

Ovulation.—Ovaries and oviducts of four cotton mice were sectioned at different stages of the vaginal cycle in order to correlate the latter with time of ovulation. Results of this investigation are as follows. *Proestrum:* The female used to illustrate this stage had been in proestrum for about eighteen hours. The smear picture at death showed a predominance of nucleated cells. The reproductive tract was moderately distended and vascular. Ova were not found in the oviducts, but large, superficially-located follicles with well-developed antra were present in each ovary. The ova were surrounded by coronal cells; cumuli were intact, but slender. *Estrum:* In this case the female had evidenced a cornified smear picture for about twenty-four hours. The reproductive tract, at death, was swollen and vascular. Three ova, one of which is shown in Plate I, a, were recorded from the ampulla of the oviducts. Two were present in one oviduct, one in the other. Each was surrounded by a mass of coronal cells; spindle fibers were clearly discernible in each case. Two polar bodies were seen, one in the process of dividing. *Metestrum:* This female had been in the metestrous stage for about twenty hours. The reproductive tract, at death, was moderately distended and vascular. Three ova were recorded from the isthmus of the oviducts (two in one, one in the other). Signs of degeneration were evident. Coronal cells were absent, and the cytoplasm evidenced a granular condition. According to Lewis and Wright (1935: 124) the coronal cells surrounding the ova of the house mouse are usually lost by about twelve hours after ovulation, always in the upper end of the oviduct. Maturation spindles or polar bodies were not recorded in the case of the cotton mouse under consideration. An example of one of the ova is shown in Plate I, b. *Diestrum:* The female representing this stage had been in diestrum for about forty hours. Upon dissection the reproductive tract was found to be pale and anemic. No ova were found in the oviducts. Many medium-size follicles were present in each ovary. Two large follicles were also present in each.

Ovulation in the case of the house mouse can occur in early, middle, or late estrum (Lewis and Wright, 1935: 119). In the cotton mice discussed above, ovulation had not occurred in late proestrum while the condition and location of the tubal ova of the one killed in late estrum indicates that ovulation had occurred recently in this animal.

External signs.—Allen (1922: 304) demonstrated that the condition of the external genitalia is not a reliable indicator of estrum in the case of the house mouse. Well-marked ex-

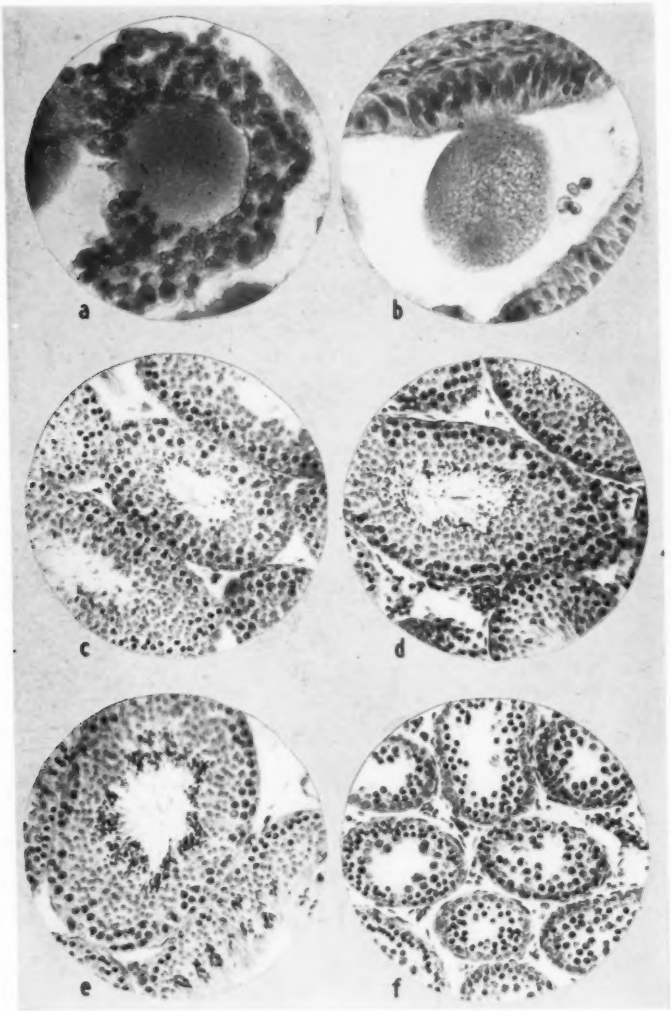

PLATE I

Ovum from: (a) Upper end of oviduct of mouse killed during late estrum. Evidence of recent ovulation is given by investing coronal cells, intact maturation spindle, and position in ovarian end of oviduct. (b) Isthmus of oviduct of mouse killed in late metestrum. Lack of coronal cell investment and granular appearance of cytoplasm indicate degeneracy. Seminiferous tubules of cotton mouse, (c) age 40 days, (d) 50 days, (e) 60 days, and (f) adult, taken June 2, 1949; typical condition of males during summer.

ternal signs—gaping of the vaginal orifice and edema of the vulva—were apparent in only 5.35 per cent of his cases. Some animals evidenced continuous external signs through the diestrous stage. The latter condition was believed to be due to conjestion and consequent poor tonus of the muscle layers of the vagina.

The following observations were made on the condition of the vaginal orifice of the cotton mouse at various stages of the cycle. Female no. 1 evidenced a gaping vaginal orifice from about the middle of the proestrous stage to mid-metestrum of her first cycle, and from early estrum to mid-metestrum of the second cycle. The orifice was not observed to be open again until early proestrum of the fourth cycle, and closed again during the following metestrum. The orifice of mouse no. 3 was observed to be open from early proestrum to mid-metestrum of the first cycle and from late proestrum to mid-metestrum of the second and final cycle observed. It was closed at all other observations except one during diestrum of the second cycle. Mouse no. 5 evidenced an open vagina from late proestrum to early metestrum of her first observed cycle. It was not found to be open again during this or the succeeding cycle. Female no. 2, observed through two cycles, evidenced a partially open orifice at all examinations.

The foregoing observations, while few, indicate the variability of conditions of the external genitalia of the cotton mouse during the estrous cycle. A tendency is noted for the vagina to remain partially or completely open during estrum and to be closed during the diestrous interval. These conditions, however, can not always be relied on, as is shown in the cases of the mice discussed above. Frequent smearing may influence the condition of the external genitalia.

GESTATION

Data are available on the gestation periods of eight litters of cotton mice, calculated as the intervals between mating of the parents and birth of the litters. Four of these litters (nos. 20, 35, 36, and 72) were born as a result of post parturition matings. In the latter three cases, former litter members were killed at birth.

By shortest period is meant the interval between isolation of the female and the earliest time at which parturition could have taken place as determined by frequent examinations for litters. The longest period was, of course, the interval between the time of introduction of the male into the cage with the female and the discovery of the litter. In some cases vaginal smears were examined for spermatozoa. When this procedure was followed, the time of mating was delimited by two successive smears, the first negative, the second positive for spermatozoa. The interval between the taking of the first (negative) smear and discovery of the litter was, of course, the longest possible gestation period.

The average of seven periods, calculated from non-nursing females, was 22.86 days for the shortest time and 23.34 days for the longest. In the case of the parents of litter no. 36, though mating was not observed, it was believed to have just occurred as scuffling was heard in the cage which was in a small room adjacent to my office. The external genitalia of the female was moist when examined and large numbers of spermatozoa were present in the vaginal smear. A smear taken one and one-half hours previously contained no spermatozoa. When the litter was discovered parturition had evidently just occurred. Two of the young were lying on the floor near the female; she was cleaning the third (calculated gestation period, 22.8 days).

It has been demonstrated that lactation prolongs gestation in other species of *Peromyscus* (Svihla, 1932: 13). A single gestation record for a lactating female cotton mouse indicates that this fact holds true for this species as well. The period of gestation for this female (litter #20) was between 29.6 and 30.8 days. Work on the house mouse, *Mus musculus*, has shown that the prolongation of gestation in lactating females is due to a failure of the blastocysts to implant in the uterus as early as in non-lactating females (Kirkham, 1916).

Three trapped females, two of which were nursing, were kept in isolation for twenty-five days before they gave birth to litters as a result of field matings. One additional nursing female gave birth after twenty-four days in isolation.

PARTURITION

Most cotton mouse births take place during the morning hours. Of twenty-six litters in which parturition time was determined to within six hours, seventeen (65.4 per cent) occurred between six A.M. and noon, while four (15.4 per cent) took place between noon and six P.M. No definite record was obtained for a nocturnal parturition although three litters were born in traps left out over night.

The predominance of morning births may be an adaptation for the nocturnal cotton mouse as this is probably a time during which the female is in her nest and free of the hazards of producing a litter in whatever spot she may happen to be during her nightly excursions for food.

Several cotton mouse parturitions were witnessed. The following observations were made on individuals trapped at Welaka during the late fall and winter of 1947–48.

Female no. 58 was observed to be in late pregnancy at capture on October 29. She was kept under close observation until she gave birth to a litter of four on November 1, between 8:25 and 9:01 A.M. She was quite active during the night previous to birth and moved restlessly about the confines of the aquarium. It was noted that she stretched frequently at full length along the floor and also vertically against the glass walls. Occasional fetal movements were observed at these times.

The following morning she had quieted down and appeared to be asleep in a corner. During about forty-five minutes in which she was watched more-or-less continously by my wife or myself, no movements were noted. At 8:25 she awoke suddenly and arose on her hind feet. The first birth was seen to be in progress, and I was called into the room. I arrived to find the female crouching on hind feet carefully licking a new-born mouse. The placenta was still attached to the young animal by means of the umbilical cord and was yet undelivered. It quickly appeared and was eaten by the female. During this process the cord was severed at about its midpoint. The female again turned her attention to the young and resumed cleaning it with her tongue. She suddenly crouched and closed her eyes, while ripples of muscular contractions ran over her body. The second young appeared (in breech position). She tugged gently at it with her teeth and began cleaning it before it was completely clear of the vaginal tract. She then held it in her forepaws and licked it thoroughly, turning it in all directions. The placenta and cord followed immediately and were eaten in the same manner as in the first case. She then returned to her task of cleaning the second mouse, giving the first-born, which was lying at her feet, an occasional lick. The third birth (breech), and also the fourth (head foremost), took place in essentially the same manner as the first two. It was noted in the case of this female, as well as in all others observed, that the collapsed membranes were the first parts of the afterbirth to be eaten.

The entire birth process consumed thirty-six minutes from the time of appearance of the first member of the litter until the final afterbirth was eaten. During the period of parturition the mother did not assist the births with her forepaws, clean the genital area, or move from the corner in which she was first discovered. On completion of birth she gave all of the young mice a careful cleaning and nipped at the umbilical remnant of each. The young emitted a few weak squeaks during the cleaning process. One mouse (born head foremost) could be heard before it was completely free from the birth canal. They made a few unsuccessful attempts to nurse while the mother slept. She awoke in about an hour and began cleaning them again. They were then allowed to nurse.

Female no. 57, captured on October 29, was also observed to be pregnant though, in her case, birth did not take place until November 4, between 10:05 and 11:09 A.M. This mouse was not as active as the preceding one, and as parturition time drew near she slept much more, stretching occasionally at full length on the floor. She was not observed to stretch up against the side of the aquarium as was the habit of the first mouse.

After sleeping most of the morning on November 4, she awoke at 10:05, stretched, then crouched on all fours and reached back to lick the genital region. The first young (breech) appeared, whereupon she began licking and tugging gently at it with her teeth. After the

hind quarters were well exposed she arose on her hind feet and, pressing the lower abdomen just above the genital region with her forepaws, seemed to attempt to aid delivery, at the same time that she tugged with her teeth or licked the young mouse. The placenta appeared immediately after the expulsion of the young, and was eaten. The entire process up to this point had consumed eight minutes (time 10:13). She then licked the young mouse thoroughly, nipped at the remains of the cord, and rested.

At 10:45 the hind quarters of the second young (breech) appeared. The delivery was essentially the same as in the first case. The afterbirth was eaten by 10:56. The third birth (breech) followed almost immediately; expulsion of the placenta was aided by the mother tugging with her teeth. At 11:03 the fourth birth (head foremost) began, and was similar to the third. The afterbirth was again pulled out and eaten, the whole process being completed by 11:09. The parent did not give the litter a second cleaning, but covered herself with cotton and went to sleep, leaving the young mice scattered about the floor of the aquarium. She was watched for about an hour longer and then at intervals until 4:00 P.M. During this time she remained under the cotton. When examined the next morning it was found that she had eaten the entire litter.

Female no. 67 was captured on November 17, and gave birth to a litter of four on November 19, between 9:28 A.M. and 10:53 A.M. Vigorous fetal movements were noted on November 18 at 7:35 A.M. On the morning of parturition this female was quite restless; she stretched frequently and rolled from side to side on her abdomen. At 9:28 she crouched on hind legs with legs well spread. The first young appeared (breech). She tugged at it with her teeth and licked it thoroughly. The attached placenta appeared a few seconds later and was eaten, the umbilical cord being separated close to the body of the young mouse in the process. Suddenly she flattened against the floor while ripples ran over her body; she then arose on hind feet and, looking down, placed her forepaws against her sides just above the vulva. At 9:38 the second young appeared (breech). The delivery was similar to that of the first born. The mother washed both mice with her tongue and nipped at the remnants of the two cords. At 9:43 she flinched as if in pain and closed her eyes; at 9:45 the third delivery began (breech). The cord was broken by stretching as the afterbirth appeared. At 10:51 the fourth and final member of the litter was born (head foremost). The afterbirth was consumed by 10:53. The mother then carefully cleaned all of the young and rested.

About an hour later a male was placed in the aquarium. The mother attacked him at once, chasing him around the aquarium and even climbed to the top of a water glass and sprang down on him. He was finally taken out.

Female no. 31, captured on October 10, gave birth to a litter of four on December 27 as a result of a laboratory mating. She had given birth to one young and was eating the afterbirth when it was noticed that parturition was taking place (7:10 A.M.). The births of the remaining three offspring (all breech) were very similar to those described for no. 58; the second appeared at 7:25, the third at 7:36, and the fourth at 7:51. By 7:55 the final afterbirth had been eaten.

Female no. 97, captured April 9, 1948, gave birth to a litter of three on April 11. The parturition pattern also followed that of no. 58 very closely. The first-born made its appearance at 9:58 A.M. and was completely expelled by 10:00. Delivery was a head presentation in this case. The second appeared at 10:34 (head), and the afterbirth was consumed by 10:38. The third and final litter member (head) appeared at 10:49 with delivery completed by 10:50. The afterbirth followed immediately and was eaten by 10:53.

The births of seventeen cotton mice from five litters were recorded. The total parturition times for four litters of four mice each were thirty-six, forty-five, sixty-four, and sixty-seven minutes. One parturition for a litter of three consumed fifty-five minutes. Eleven births (64.7 per cent) were breech presentations while six (35.3 per cent) were expelled head foremost. In all cases the afterbirth was eaten immediately with the collapsed membranes being the first part consumed.

The placenta of the cotton mouse is buttonlike in shape. Measurements of the diameters of two placentae from the offspring of different parents were ten and eleven millimeters. The lengths of the respective umbilical cords were fifteen and fourteen mm.

LITTER SIZE

Seventy-two litters of cotton mice, totaling 265 individuals, were born in captivity during the course of this study. Sizes of these litters ranged from one through seven with a mean of $3.7 \pm .14$ and a mode of four. The sex ratio at birth, computed from sixty-four litters totaling 240 mice, was 49.58 per cent (119) males and 50.42 per cent (121) females. As there was no indication of selective female mortality during growth of the young, the high percentage of wild trapped males (56.98 per cent) suggests a greater activity of this sex under natural conditions.

No significant difference was found in mean litter size of twenty-three litters born as a result of field matings in February, March, April, and May, when compared with the mean litter size of thirty-three litters born in September, October, November, and December. In the former case the mean was $3.6 \pm .24$ while in the latter case it was $3.9 \pm .19$.

Data on 126 embryos from thirty-two pregnant females demonstrated a mean litter size of $3.9 \pm .16$ with a mode of four and range from two through six. The mean litter size is thus higher, but not significantly so, when computed from these embryos than when figured on the basis of newborn. In other species a significantly higher figure is sometimes obtained for embryos than for newborn animals. This condition may possibly be due to early prenatal resorption. My figures are compiled on embryos of at least a week of age.

Seventy embryos (55.5 per cent) were found in the right horn of the uterus and fifty-six (44.5 per cent) in the left horn.

DEVELOPMENT

Newborn cotton mice are pink and hairless except for fine vibrissae projecting from raised papillae on the upperlip. The skin is quite wrinkled, the eyes are closed, incisors unerupted, and the pinnae are folded down over the external ear openings. Claws are present on all toes of both fore and hind feet. When handled or otherwise disturbed, the young mice emit very faint, high pitched twitters which are almost above the range of human hearing. This was noted in one instance, as mentioned previously, even before the mouse had been completely born.

On the second day the back becomes considerably darkened although the abdomen retains its pinkish hue. Shortly after this, usually on the fourth day, the pinnae unfold. In thirty-eight cases out of forty-eight individuals examined, eruption of incisors took place on the fifth, sixth, or seventh day. In nineteen of these cases (39.6 per cent) eruption occurred on the sixth day.

By the fifth day the back has become quite dark, and very fine hairs are present. The abdomen is still pink and hairless. From about the fifth to the tenth day the mice undergo their most radical change in appearance. During this interval hair grows rapidly on both back and abdomen, and the animals lose the naked, almost fetal appearance which is quite marked during the first few days. On about the tenth day, or slightly later, they evidence the alert, nervous manner that is characteristic of this species. Movements are much more directed, and, even before the eyes are open, there is a tendency to react quickly to noises, handling, and other stimuli.

It was at about this age, just prior to opening of the eyes, that the young mice proved most difficult to handle without injury to themselves or to the mother. They remain attached to the female more or less continuously, and have developed to the point where they hang tenaciously to the nipples. Attempts to separate them from the mother have resulted in tearing the nipples of the parent completely from the body.

The eyes of fifty-nine young cotton mice, out of a total of 151 records, opened on the 13th day. In the case of two individuals, opening was as early as the 10th day; in two more it occurred on the 11th, and in four as late as the 18th day. In 75.5 per cent (115) of the cases opening of the eyes took place on the 12th, 13th, or 14th days. The remaining 18.5 per cent (28) opened on the 15th, 16th, or 17th days.

In thirty-six litters, totaling 136 individuals, the eyes of litter mates opened on the same day. In four additional litters, totaling fifteen mice, eyes opened on different days. In no

case was a difference of more than one day observed between the opening of the eyes of the first and last members of a particular litter.

By the 15th day the underparts of the mice become darkened and assume a grayish-white appearance. This is due to the gray color of the base of the hair which has now grown out.

Cotton mice in the laboratory were usually separated from the mother at from twenty to twenty-five days of age and suffered no ill effects. Prior to this time they were already nibbling at solid food. That these animals are nutritionally independent of the parent at quite an early age was demonstrated by isolating two young mice, members of separate litters, male and female, from the parents on the days that the eyes opened (13th and 14th days, respectively). These mice were given the regular ration of Frisky Dog Checkers with lettuce supplements. Both mice lived to adulthood; no ill effects were noted as a result of this premature weaning.

The longest that a litter (of two) was observed to nurse was thirty-three days; another litter (of three) was observed nursing on the twenty-ninth day. It is common for the parent to exhibit such maternal traits as hovering over the young and cleaning them at a comparatively late age.

Most cotton mouse mothers used in this study were good parents. Six litters out of a total of fifty-eight were eaten soon after birth, but in only two cases was there no apparent reason. In the remaining four cases, two of the females had been disturbed by unavoidable rough handling just prior to parturition, another was found to be heavily parasitized by nematodes, and the fourth had been upset by the introduction of a strange male into the cage just after she had given birth to the litter.

One of the remaining females was quite nervous in temperament. This trait had been evidenced since her capture eight days previous to the birth of her litter. She was never observed to use the nest bottle in her cage, but always pulled the cotton out and into a corner of the pan. She spent much time moving restlessly about her confines and was always difficult to catch for routine examinations. In the case of the final female, there was no apparent reason for her action. She appeared healthy, docile, and had not been disturbed more than an average amount.

Usually females were quite solicitous toward their young. Attempts to separate a litter member for examination were met with determined resistance. When the young were returned to the cage the mother invariably grasped them by the abdomen with her mouth, carried them back to the nest, and gave them a thorough cleaning with her tongue. Many times they were taken directly from my hand. The odor of ether that was sometimes present on anesthetized young did not affect her attitude towards them in the least.

Mention has been made of inadvertently tearing the nipples from the body of the mother in attempts to dislodge the nursing young. Even this did not cause the female to refuse to nurse the litter when it was returned to her.

Records of observations of ninety individuals demonstrate that cotton mice usually begain their first molt from the 34th to the 40th day. In sixty-nine cases (76.7 per cent) molt began during this time. Individual cases ranged from the 32nd to the 53rd day. In most cases the molt line is well defined. It is first evidenced as a band of adult pelage along each side of the body. This band lengthens anteriorly over the shoulders and side of the face, posteriorly over the flanks, and, at the same time, extends dorsally. The last remnant of juvenal pelage is usually found above the base of the tail. This small section is quite persistent. It was still present on one mouse at ninety-four days of age. In the case of some individuals it is extremely difficult to discern molt due to its very gradual appearance over the entire dorsal surface of the body.

SEXUAL MATURITY

Testes of thirty-two cotton mice, from thirty-five to seventy-two days of age, were sectioned in order to determine the time of appearance of mature spermatozoa. Epididymal examinations were also made and testes lengths, exclusive of the epididymis, were recorded. These data are summarized in Table 1.

Mature spermatozoa were not found in seminiferous tubules of mice under forty days of age (Pl. I, c, d, e) although a few spermatids were present in one individual thirty-eight days old. In three out of five forty-day-old animals mature germ cells were present in relatively small numbers in the tubules, however, none was found in the epididymis of specimens under forty-five days of age. By the 70th day both tubules and epididymides contain great numbers of spermatozoa. One of the seventy-day-old individuals, whose testes meas-

TABLE 1.—*Development of testes of young cotton mice*
(x, spermatozoa present; 0, spermatozoa absent)

AGE (DAYS)	TESTES, LENGTH (MM.)	MATURE SPERMATOZOA PRESENT IN	
		Epididymis	Seminiferous Tubules
35	5	0	0
35	7	0	0
35	7	0	0
35	6	0	0
35	6	0	0
38	8	0	0
38	6	0	0
40	?	0	x
40	7	0	0
40	5	0	0
40	10	0	x
40	9	0	x
42	?	0	x
45	7.5	?	x
45	10	x	x
45	10	x	x
45	9	x	x
50	10	x	x
50	9	x	x
50	10	x	x
50	10	x	x
50	9	x	x
55	10	x	x
55	9	x	x
55	?	0	x
60	10	x	x
60	10	x	x
60	8	0	x
65	?	x	x
70	13	x	x
70	12	x	x
72	11	x	x

ured twelve millimeters in length (Table 1), had undergone a fertile mating with its parent sometime prior to its death at seventy days.

In other species of rodents somewhat similar results have been obtained. Mature spermatozoa were found in the epididymis of one forty-day-old *P. eremicus* out of eight examined, and twenty-nine out of seventy-nine mutant hybrid males of *P. maniculatus* stock (Clark, 1938: 232). Meyer and Meyer (1944: 125) state that epididymal smears of forty-day-old cotton rats occasionally contain mature germ cells. Sperm heads in the tubules of *Rattus rattus* of thirty-three to thirty-five days of age are mentioned by Asdell (1946*a*: 282).

Vaginal introitus has been used as an indicator of puberty in the American field mouse (Hamilton, 1941: 6), the cotton rat (Clark, 1936*b*: 1), and the house mouse (Snell, 1941. 58).

Thirty-six young female cotton mice were examined daily in order to discern the age of initial opening of the vagina. Of these, nine failed to open by the sixty-fifth day. The average age of opening of the remaining twenty-seven animals was forty-three days. The earliest opening was recorded on the 36th day. The average age of vaginal introitus of thirty-two females of a laboratory stock of *P. leucopus* was found to be forty-six days (Clark, 1938: 232). The youngest *P. leucopus* female that underwent a fertile mating was thirty-nine days of age at conception. My earliest record of a fertile mating of a female cotton mouse was for one of seventy-three days of age.

GROWTH

Data concerning the growth of young cotton mice from the day of birth through the 60th day of age are included in Table 2. Measurements of 428 adults trapped in the vicinity of Welaka, Florida, during 1947–48 are also given in Table 2. No pregnant females are included.

TABLE 2.—*Growth of the cotton mouse. Each measurement based on 45 individuals. Measurements in millimeters, weights in grams*

AGE	TOTAL LENGTH	LENGTH OF TAIL	HIND FOOT	WEIGHT
1st day	47.16 ± 0.22	10.98 ± 0.10	6.53 ± 0.06	2.19 ± 0.03
10th day	82.00 ± 0.70	27.7 ± 0.49	15.5 ± 0.19	6.98 ± 0.22
20th day	126.6 ± 1.16	50.9 ± 0.67	21.0 ± 0.18	12.30 ± 0.36
30th day	147.8 ± 0.89	61.9 ± 0.50	22.9 ± 0.13	18.00 ± 0.34
42nd day	159.2 ± 0.71	67.7 ± 0.56	23.3 ± 0.10	22.21 ± 0.45
50th day	163.8 ± 0.91	69.3 ± 0.56	23.4 ± 0.10	23.64 ± 0.47
60th day	166.7 ± 0.84	70.6 ± 0.54	23.4 ± 0.11	25.50 ± 0.51
Wild adults*	178.8 ± 0.41	74.7 ± 0.27	23.2 ± 0.04	29.02 ± 0.23

* 428 adults trapped in Putnam County, Florida, from September, 1947, to September, 1948. No pregnant females are included (283♂♂, 145♀♀).

On the day of birth the mean total length (47.16 mm.) of the mice was found to be 26.3 per cent of the mean adult length (178.8 mm.). By the 13th day the total length had doubled. Growth continued at a rapid rate, and by the 30th day the length was approximately 83 per cent (147.8 mm.) of that of the adult. Following this period there was the usual flattening of the growth curve. By the 60th day the total length was 166.7 mm., about 93 per cent of the adult figure.

The tail length (10.98 mm.), dealing with the average in each case, on the first day was 14.7 per cent of the adult tail length (74.7 mm.). By the seventh day the length of this organ had doubled, and by the 30th day it was about 83 per cent (61.9 mm.) of that of the adult. As in the case of the total length, a retardation of growth was then noted. On the 60th day the tail length was 70.6 mm., 94.5 per cent of the adult size.

The length of hind foot at birth was approximately 28 per cent (6.53 mm.) of the adult average (23.2 mm.). Length doubled by the eighth day, and by the 30th day the foot had reached approximate adult size (22.9 mm.). This is before any sign of molt can be detected on the young mouse. The length of foot of the mice on the 60th day averaged slightly more than the average of the wild trapped animals. No explanation is evident for this difference.

On the day of birth the average weight of the mice (2.19 grams) was 7.6 per cent of the adult weight (29.0 grams). There was a rather constant gain of about .53 gram a day until the 30th day at which time the animals exhibited a mean weight of 18 grams, 62 per cent of

the adult weight. Gain for the remaining thirty days was at the rate of about .25 gram a day. By the 60th day the average weight was 25.5 grams, 88 per cent of the adult average. It is recognized, however, that even though exercise wheels were available to the mice, and were used a great deal of the time, it is quite possible that they did not get as much exercise in the cages as would have been possible in their native habitats. This, coupled with a constant food supply, may have tended to make the weights of the laboratory mice somewhat greater than those of their wild brethren of corresponding age.

In summary, it was found that the most rapid post-natal growth of the cotton mouse takes place during the first thirty days. By this time 82.6 per cent of the adult total length, 82.9 per cent of the length of tail, practically all of the growth of the hind foot, and 62 per cent of the adult weight has been attained. By the 60th day the total length is 93.2 per cent of the adult mean, the length of tail is 94.5 per cent of adult size, and the weight is 88 per cent of the adult average. Dice and Bradley (1942: 426) have found, in work with the deer mouse, *P. maniculatus*, that, aside from the hind foot, which lengthens only slightly or not at all after six weeks of age, the mice grow slowly until they attain the age of six months or older. They suggest that sexual maturity may be an important factor in slowing down growth since the change from a high juvenile rate to a slower adult level corresponds in general to time of approaching sexual maturity.

In an earlier report, Dice (1932) found that prairie deer mice, *P. maniculatus bairdi*, of two years of age averaged larger in every measurement than did those of one year of age.

SEASONAL BREEDING

Pregnant females were trapped during all months of the year except June and July (Table 3), and but two litters were born in June as a result of laboratory matings. Highest monthly percentages of pregnancies were recorded for November (62.8 per cent), December (69.2 per cent), and January (51.8 per cent). Only one pregnancy was recorded (August 3, 1948), out of a total of 113 adult females examined, during the months of June, July, and August, whereas fifty pregnant females were recorded from a total of 83 examined in November, December, and January. The greatest number of litters produced in a single month in the laboratory, as a result of field matings from September 28, 1947, to September 28, 1948, was nine for December.

Evidence has been presented in a previous section that sexual maturity is attained by the cotton mouse, under laboratory conditions at least, by about two months of age. Individuals born during the early part of the fall breeding season may, therefore, produce offspring during the same season. A captive female, for example, born September 30, 1949, mated on December 12, 1949, and produced a litter of four on January 4, 1950. Spring-born mice evidently undergo a resting period during most of the summer and reproduce the following fall, as no pregnant females were recorded in June and July and only one in August.

Data from females that were lactating and also pregnant at capture indicate that individuals produce litters in succession during the breeding season. Twenty-three records are available of females recently nursing at capture, which later gave birth to litters or were killed and found to be pregnant.

One female gave birth to four litters, as a result of laboratory matings, in less than six months. Her litters were born on January 12, litter of four; April 17 (approximately), litter of two; June 5, litter of three; and June 28, litter of three. The male parent of the last two litters had been in captivity for about one and one-half years. It was an adult at capture, weight thirty-one grams, consequently its age at birth of the last litter was probably at least two years.

Another female gave evidence of having borne three litters during the fall of 1947. Two of these litters were results of matings in the laboratory. She was lactating when captured on October 9, and gave birth to successive litters on November 23 and December 24. Barrington (1949: 52) gives evidence, through trapping records, of a female cotton mouse bearing three litters in a single year. This animal was lactating when captured in February and again in April. She was nursing when retaken the following November. It is interesting to

note that the biotic potential of a single cotton mouse female for a two-year period is 528,941, assuming seven to be the maximum litter size and six to be the maximum number of generations in a single year.

Lengths of testes were recorded on 364 adult male mice taken throughout the year. Monthly averages are presented in Table 3. From September through December, testes

TABLE 3.—*A summary, by months, of average lengths of testes and percentages of breeding male and female cotton mice*

MONTH	MALES			FEMALES	
	Total Examined	Testes, Length, mm.	Per Cent Breeding	Total Examined	Per Cent Pregnant
January	19	13.4	79.0	27	51.9
February	21	13.3	76.3	24	20.8
March	28	10.2	50.0	20	50.0
April	26	7.7	19.2	21	14.4
May	25	7.9	8.0	24	16.6
June	70	7.1	7.2	53	00.0
July	58	7.7	10.3	46	00.0
August	45	13.6	86.7	14	7.2
September	19	15.1	94.7	18	44.4
October	15	15.9	100.0	25	24.0
November	25	14.6	92.0	43	62.8
December	13	15.5	100.0	13	69.2

TABLE 4.—*Comparison of testes of adult male cotton mice kept at different temperatures (x, sperm present; 0, sperm absent)*

TIME IN EXPERIMENT, WEEKS	EXPERIMENTAL GROUP (89 TO 101 DEGREES F.)			CONTROL GROUP (63 TO 84 DEGREES F.)		
	Testes, Length, mm.	Sperm Present		Testes, Length, mm.	Sperm Present	
		Epid.	Tubules		Epid.	Tubules
one	11	x	x	13	x	x
	11	x	x	12	x	x
two	12	x	x	12	x	x
	12	x	x	10	x	x
three	8	0	x*	13	x	x
	7	0	0	11	x	x
four	7	0	x*	12	x	x
	7	0	0	11	x	x

* Very few spermatozoa present.

averaged between 14 and 16 mm. in length. There was then a gradual decline to a low of between 7 and 8 mm. in May, June, and July. In August an increase in length to about 13.5 mm. occurred.

Examinations of the epididymides of most of the mice, and sections of the testes of ninety-eight individuals, demonstrated that the dividing line between testes with many spermatozoa and those with few seemed to be at about the 10 mm. length. Percentages of breeding males, as judged by lengths of testes, based on the above criteria, are given in Table 3.

From the latter part of April until August the reproductive activities of the males are at a low ebb. Testes are shrunken and retracted; the cauda epididymis which, when active, is quite prominent as a posterior projection on the testis, is, during this period, almost microscopic and lies buried in the fat body of the testis. The interstitial cells appear small and spindle shaped. A section of the testis of a large male taken on June 2, 1949, is shown in Plate I, f. The absence of spermatozoa and the shrunken condition of the tubules is evident at a glance.

Sixteen adult male cotton mice were used in an effort to determine the effect of temperature on the testes. Eight of these animals were placed in an incubator provided with a hardware cloth top. The remaining eight mice, used as controls, were kept at room temperature in an aquarium which was also fitted with a hardware cloth top. Temperature readings in the incubator varied from 89 to 101 degrees F., while variations in room temperature from 68 to 84 degrees F. were obtained.

Two mice from the experimental group and two controls were killed each week over a four-week period. Lengths of testes, exclusive of the epididymides, were recorded, examinations of epididymides were made and sections of testes from each animal were examined. This experiment was conducted during the months of March and April, 1950. Results are summarized in Table 4.

No spermatozoa were recorded in epididymal examinations of mice subjected to incubation for three weeks or longer. The tubules were shrunken and showed a paucity of spermatozoa. McNair (1931: 49) found that *P. maniculatus* and *P. leucopus* stocks kept at high temperatures did not breed as well as did those in cooler situations. Twenty-seven per cent of the animals kept under greenhouse conditions were judged to be breeding while fifty-eight per cent of those kept in a cooler part of the building reproduced. Griffith and Farris (1942: 2) considered a temperature of 72 degrees F. with no more than 5 degrees variation essential for satisfactory breeding in the case of the laboratory rat, *Rattus* sp.

It is probable that high summer temperatures is one of the factors influencing cyclic reproduction of the cotton mouse in North Florida, although other factors, no doubt, also enter into the picture since there is an increase in the size of the testes of wild-trapped mice during early August. Many factors such as changes of temperature, food, humidity, rainfall, and light play varying roles in different species according to a summary by Bissonette (1936: 383). Fall breeders do not give a clear cut response to changes in light according to Asdell (1946*a*: 14).

SUMMARY

The results are presented of a study of the reproductive activities and early post-natal development of the cotton mouse, *Peromyscus gossypinus gossypinus*, in North Florida. This study was based on observations of 888 wild-trapped and 265 laboratory-reared individuals.

The estrous cycle resembles that described for the deermouse, *P. maniculatus bairdi* (Clark, 1936*a*), except in the following points: (1) An estrous smear composed entirely of cornified cells was not often found; usually small numbers of nucleated cells and an occasional leucocyte were also present. (2) Metestrum was sometimes characterized by appearance and gradual increase in leucocytes concurrent with disappearance of cornified cells, no great influx of nucleated cells being recorded.

The average length of the estrous cycle was 5.26 days. Average lengths of stages were: proestrum, 21.1 hours; estrum, 23.9 hours; metestrum, 29.5 hours; and diestrum, 49.5 hours. Ovulation probably occurs during the latter part of the estrous stage.

The condition of the vaginal orifice is not an absolute indicator of heat, al-

though there is a tendency for it to remain closed during diestrum and open or partially open during estrum.

The gestation period, based on non-nursing females, was found to be approximately twenty-three days. One period, determined on a nursing female, was thirty days. The presence of a post-parturition heat period was demonstrated for this species.

Most cotton mouse parturitions take place during the morning hours. Of twenty-six litters in which time of birth was determined to within six hours, 65.4 per cent occurred between six A.M. and noon, while 15.4 per cent took place between noon and six P.M. No definite record of a nocturnal parturition was obtained.

Details of births of seventeen mice from five litters were recorded. Parturition times for four litters of four mice each were thirty-six, forty-five, sixty-four, and sixty-seven minutes. The birth of one litter of three mice consumed fifty-five minutes.

The average number of young per litter, based on 265 newborn mice from seventy-two litters, was 3.7. Sizes of litters ranged from one to seven with four being the most frequent number.

No significant difference in litter size was found between fall- and spring-born litters, or in number based on newborn mice compared with embryo counts from pregnant females.

The sex ratio at birth, based on 240 mice, was 49.48 per cent males and 50.42 per cent females. The sex ratio of 888 wild-trapped individuals was 56.98 per cent males and 43.02 per cent females.

Newborn cotton mice are naked and blind; the pinnae are folded over the external ear openings; and the incisors are unerupted. During the first five days the pinnae unfold. In 39.6 per cent of the cases recorded, eruption of incisors took place on the sixth day. By the tenth day the young mice have a covering of very dark dorsal pelage which contrasts strongly with the white hair of the belly. From the 10th to the 18th day, usually on the 13th day, the eyes open, and shortly after this the mice begin to eat solid food. They are capable of existing on solid food when thirteen or fourteen days of age, but were not, as a rule, separated from the mother until twenty or twenty-five days of age.

Molt is usually first discernible from the 34th to the 40th day of age. It may be well defined, first appearing along the sides and progressing dorsally, being finally completed above the base of the tail, or it may appear gradually over the entire dorsal surface of the body.

Young cotton mice grow rapidly during the first thirty days following birth. By the 30th day the average total length and length of tail are slightly over 80 per cent of their respective adult lengths. The hind foot has attained approximately full growth, the weight is about 62 per cent of the adult average. From the 30th to the 60th day the growth curve flattens. At 60 days the total length and length of tail are each about 94 per cent of their respective adult measurements. The weight of the sixty-day-old individual is 88 per cent of the adult weight.

Mature spermatozoa were found in the seminiferous tubules of mice at forty days of age and in the epididymides at forty-five days. By the 70th day both the tubules and epididymides contain large numbers of mature spermatozoa. Earliest records of fertile matings for male and for female mice were obtained on individuals of approximately seventy days of age.

Records of wild-trapped animals demonstrated that reproductive activities are at a low ebb during the late spring and summer in North Florida. Only one pregnancy was recorded from 113 adult females examined during the months of June, July, and August. The testes of the males are shrunken and retracted. The epididymis is small and the seminiferous tubules are reduced and lacking in mature spermatazoa. The cause of this condition in the field was not determined, although laboratory experiments demonstrated that testes of animals kept at high temperatures for three weeks evidenced conditions similar to those found in the wild males trapped during the summer. Greatest reproductive activity of the cotton mouse, under natural conditions, was found during the late fall and early winter. Fifty pregnancies were recorded from a total of 83 adult females examined during November and December, and January.

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THE ARMADILLO IN THE SOUTHEASTERN UNITED STATES

By Henry S. Fitch, Phil Goodrum, and Coleman Newman

This study was undertaken to gain more information on the status of the nine-banded armadillo (*Dasypus novemcinctus*) in the states east of the Texas border, which it has occupied mainly during the last three decades. The armadillo has spread naturally through Louisiana and a part of Mississippi. Florida now has a substantial colony as a result of accidental liberation. At least three occurrences have been recorded for Alabama. In Louisiana, as in eastern Texas, it is an aggressive new member of the fauna, with the prospect of undergoing further spread and increase and playing an increasingly important role in the ecology of the region, particularly of its forests.

For a much longer time the species has been a conspicuous member of the Texas fauna where it has been the subject of many publications and several detailed studies. Two important papers dealing with its ecology are those of Kalmbach (1944), discussing the general habits, distribution, and economic importance; and Taber (1945), considering various phases of the ecology on the basis of animals studied both in the wild and in captivity.

DISTRIBUTION

Original range and early extension.—This species, with its several geographic races, has an extensive distribution in the American tropics. It is a well established fact that for the past 70 years or more it has been gradually extending its range northward and eastward. Strecker, who first called attention to this fact, stated (1926: 207) "Until about the early seventies of the last century, the lower Rio Grande Valley was the principal home of the armadillo in Texas. It ranged in the coastal prairie region north at least to Matagorda County. . . ." The same author, citing numerous early publications and verbal accounts, traced the spread of the armadillo through southern and central Texas, into the Panhandle region on the west and eastward to the counties bordering Louisiana, stating "In the seventies, the animals had already worked their way across the Nueces, and a short time later were in the San Antonio River Valley. By 1890 they had reached the Colorado and by 1895, they probably had penetrated to the Brazos Valley. At the present time (i.e., 1926) they are found in the drainage areas of the Trinity and Neches rivers, and from the above indicated data have at Hemphill almost crossed the Sabine, and a little higher up have already crossed that stream into the alluvial bottoms between the Sabine and Red rivers."

Lowery (1943: 253) states that since 1925 the armadillo "has become extremely abundant in the pine flats of southwestern Louisiana. The species also occurs commonly in the prairies and wooded uplands of most of western Louisiana. Furthermore, it appears not infrequently east of the Mississippi River in the Florida Parishes, but in this area the species has not yet become fully established." Kalmbach (1944: 6) stated: "At the present time the armadillo is common at many points in northern Louisiana through which its main line of advance seems to have progressed. There are also a few records immediately east of the Mississippi River indicating that it had passed the most formidable barrier on a march to the east that may take it to the Atlantic Coast." He cited published records of occurrences in Alabama, Florida, and Oklahoma.

Cause of spread.—It is evident that the recent spread of the armadillo has been favored by environmental changes, probably those caused by the advance of civilization during the last century. Otherwise it might have been expected to have spread long ago into the areas which it is only now invading. The diverse ecology created by cutting of forests, introduction of agricultural crops, and grazing of livestock have doubtless had important influence

on the history of this extension of range. However, it may be surmised that the most important effect of human settlement was the reduction or local extermination of large carnivores—the red wolf (*Canis niger*), coyote (*Canis latrans*), black bear (*Euarctos americanus*), puma (*Felis concolor*), jaguar (*Felis onca*), ocelot (*Felis pardalis*), and bobcat (*Lynx rufus*). Any of these carnivores might find the armadillo easy prey, and, where abundant, might provide effective check to its increase or spread.

Further aid to the natural range extension of the armadillo has been provided by humans transporting them into areas where they did not occur naturally. It is probably no exaggeration to state that this has occurred hundreds of times, and in some instances has resulted in the establishment of permanent colonies which served as the nuclei for further expansion. Such plantings have been accidental and usually follow a definite pattern. A traveler curious upon first encountering the animal carries home one or more, which are confined, perhaps beneath a tub or barrel, or in a wire enclosure. The animals then escape by digging and return to the wild state. Such occurrences may account for some of the outstanding early records well beyond the regular range. In relatively few instances would permanent colonies result and a minimum of a pair, or a gravid female, would have to be introduced. Even then, the chances of the pair surviving and meeting at the proper time for breeding might be remote and an isolated gravid female could not give rise to a colony unless the first litter consisted of males (all four young of any litter are of the same sex). It would then be necessary for the original female to mate with a survivor of this first litter and to produce a later litter of females. In Louisiana, Florida, and Mississippi many of the persons interviewed cited definite instances of such introductions, and attributed the present local populations to such sources. Relatively few people are aware of the gradual and continual spread which has occurred.

Tracing of dispersal.—On several field trips in Louisiana, Arkansas, Alabama, Mississippi, and Florida, we interviewed hundreds of persons to obtain evidence as to the presence of armadillos at specific localities, and the time of their first appearance. We were, of necessity, somewhat uncritical in selecting our subjects for these interviews, being usually unfamiliar with the locality or its inhabitants. In some instances we contacted game wardens or other officials, but many of our informants were contacted at farms, country stores, or filling stations. Local newspaper offices sometimes had usable records. The majority of persons interviewed gave straightforward answers which impressed us as being fairly reliable, and most of them evinced much interest. In areas where the animal was rare or unknown our questions evoked surprise or incredulity. Where the animal was well known, longtime residents were sometimes able to remember their first encounter with it, and often could recall with certainty the month or at least the year of such observations. It was soon apparent that the animal may exist in small numbers in an area for many years without being known to the majority of rural people. Persons who spend much time in the woods, especially trapping or hunting with dogs, are more apt to come in contact with armadillos, while persons of more sedentary and confining occupations may be unaware that the animal exists years after it is well established and common. Accordingly, some of our records represent occurrences noticed only after the species was well established and becoming abundant years after its original invasion. For other areas our records may represent the early years of establishment or even forerunners before a breeding population was present. Such irregularities somewhat obscure the trend of the actual population movement which probably has involved a steady progression eastward. The accompanying maps (Figs. 1 and 2) are based on the records gained from interviews with local residents and supplemented by a few records from the literature. The general history of the armadillo's spread in the southeastern states, shown on the maps, is further clarified by a brief statement for each state where the animal is known to occur.

New Mexico.—Bailey (1931), in his study of the fauna of this state, considered the armadillo to be a rare resident of the extreme southeastern portion, whence it had immigrated from west-central Texas.

Texas.—Since 1880 the armadillo has apparently spread throughout the greater part of

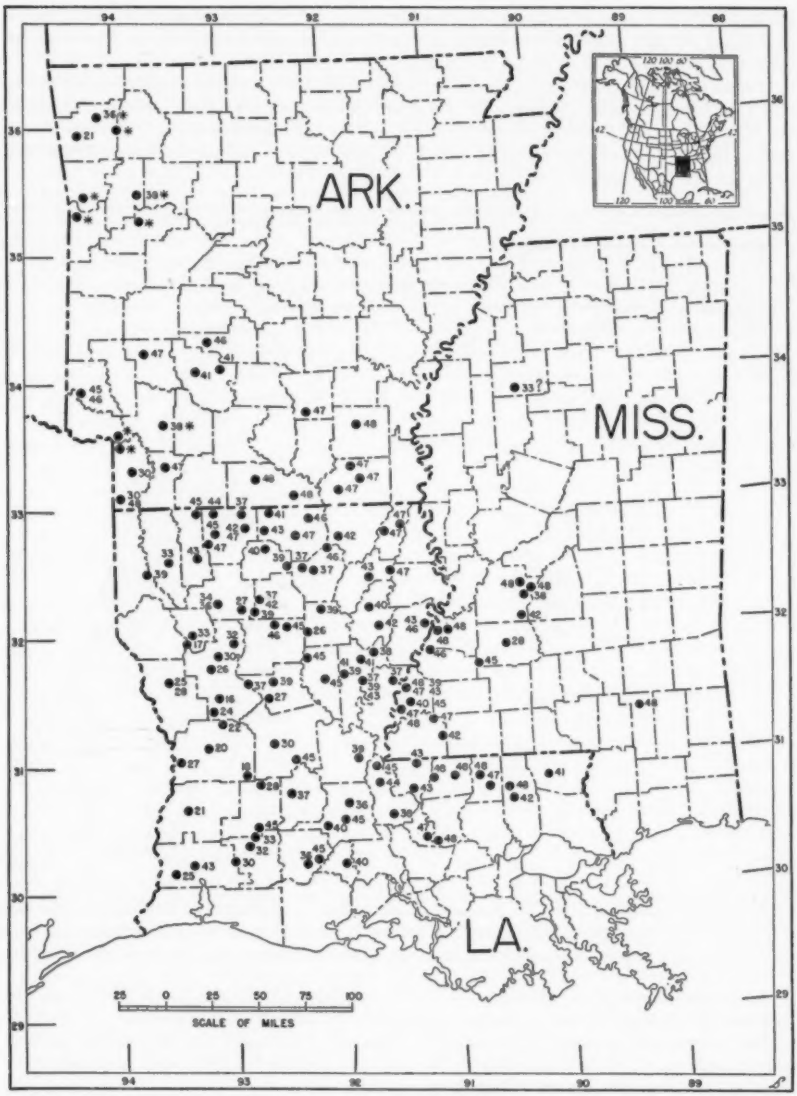

FIG. 1.—Occurrences and spread of the armadillo in Louisiana, Arkansas, and Mississippi. Black dots with figure above indicate locality and earliest date the animal appeared in the various parishes and counties.

the state. The Texas Game, Fish, and Oyster Commission (1945: op. p. 136), mapping the known range at the time of publication, indicates that it is unknown from: (1) nearly all of

the trans-Pecos region of extreme western Texas, and (2) that portion of the state north of latitude 30° 20′, including the entire panhandle region, and a strip one to four counties wide bordering the Red River on the south.

Oklahoma.—Blair (1936) records the armadillo from the northeastern part of the state, at Tulsa. We were told of one seen in 1939 near Whitesboro. Kalmbach (*op. cit.*: 7) records one taken 8 mi. NW Freedom, Woods County, in 1941. He states that low temperature and aridity in this part of the range, as well as in New Mexico and northwestern Texas, are probably limiting factors.

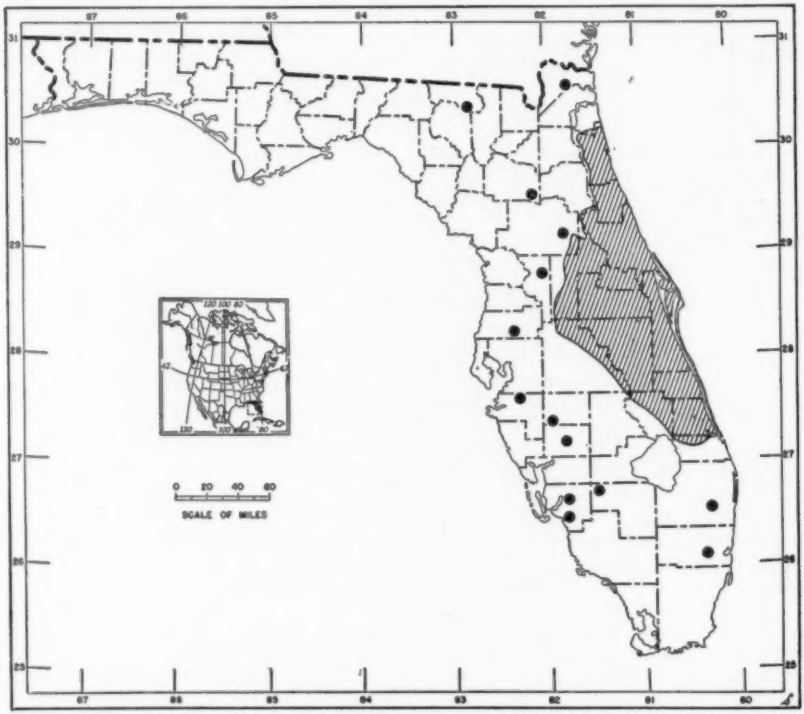

FIG. 2.—Distribution of the armadillo in Florida as of 1949. Shaded area indicates uniform occupancy; black dots, outlying colonies. Data on occurrence obtained only in 1949.

Arkansas.—Records published by Dellinger and Black (1940) and Black (1944) indicate that already in 1921 the animal had spread northward through extreme western Arkansas, nearly to its northern border. It probably is generally distributed throughout that part of the state south of the Arkansas River. We obtained records for 1947, 1948, and 1949 in 16 counties in the southern part of the state.

Kansas.—Hibbard (1944: 87) records the circumstances under which two armadillos were taken, 4½ mi. NW Caldwell, Sumner County, and near Strong, Chase County, Kansas. He suggests that the species may have reached Kansas by natural means. Lutz (1950) records two others, recently taken, 10 mi. N Pratt, Pratt County, and NW Hugoton, and still other specimens are in the University of Kansas Museum of Natural History. All Kansas records are from the south-central portion of the state from scattered localities.

Missouri.—The MISSOURI CONSERVATIONIST for May 1947 (p. 12) carried an account of an armadillo bayed by dogs and killed by a farmer in a pasture. This was at Brownington, in Henry County, near Clinton in the east-central part of the state. Since the locality is far removed from other recorded occurrences, it may be suspected that it represents a lone animal transported and released by human agency, rather than an established population.

Louisiana.—Our records indicate that armadillos crossed the Sabine River and entered the state as early as 1916 or 1917, and that during the twenties they were still uncommon, but spread steadily eastward nearly across the central and north-central portions. During the thirties they spread into the northeastern and southeastern parts of the state, and continued eastward, meanwhile becoming abundant in the western parishes where first established. During the forties they reached and crossed the Mississippi on a broad front, having completed their spread through the northern and southern parts of the state. Their occurrence in the Florida parishes of southeastern Louisiana is still sporadic. In the northeastern parishes and those bordering on the Mississippi River the armadillo is still so scarce as to be a curiosity, or is unknown to most of the inhabitants. In East Carroll and Madison parishes bordering the Mississippi River in the northeastern corner of the state, we were unable to obtain records, and evidently the animal is still very scarce—if it has reached there at all. Apparently it is not yet abundant anywhere in the northern part of the state.

On the other hand, in the west-central and central parishes, namely, De Soto, Red River, Winn, Sabine, Natchitoches, Grant, Vernon, Rapides, Beauregard, Allen, and Evangeline, the species has become extremely abundant. In this part of the state it is well known, and its crushed remains are a common sight on highways and country roads.

Hardberger (1950: 175) has recently discussed briefly and mapped the distribution in Louisiana and adjoining states. He shows the range as barely reaching Arkansas and Mississippi, but for Louisiana his data correspond fairly well with our own. He indicates the species to be "rare" in the tier of parishes bordering the Mississippi River, the Florida parishes, and the delta region; but "frequent" throughout the remainder of the state.

Mississippi.—Numerous records from eight different counties obtained east of the Mississippi River between Vicksburg and Baton Rouge indicate that the armadillo has become well established in southwestern Mississippi within the last decade. It is not yet common in this part of its range, and is known to only a minority of the rural people. Occasionally it is reported in local newspapers. At several points in Jefferson and Claiborne counties, local people, shown a sketch of an armadillo, recognized it and referred to it as "ground hog."

It is evident that the Mississippi River has not constituted a serious barrier to its eastward progress. Rivers in general may help rather than hinder its range extension. Wooded bottomlands and streamside habitats are preferred. Hence, in times of high water, areas occupied by it are apt to be inundated. Kalmbach (*op. cit.*: 20 and 21) has described the animal's habit of ingesting air to inflate the stomach and intestine, rendering it buoyant, when it is accidentally caught in the water or forced into it. By virtue of this habit, individuals caught in floods might survive to float far downstream, and eventually be cast ashore on the side opposite their starting point.

Several of our early Mississippi records indicate that the animals occurred in this state long before they had reached the west side of the river in numbers. Since the species is known to have been established much earlier in the tributary Arkansas River Valley to the northwest, the possibility is suggested that such individuals may have reached the state by being carried downstream on drift at time of flood.

Mr. I. E. Bennett, director of the Livingston Park Zoo, at Jackson, Mississippi, told us that during the depression, around 1934, when large numbers of cattle were shipped in from Texas to Rankin County just east of Jackson, live armadillos frequently were aboard and escaped from the box cars at the destination. He believed that a breeding colony had become established since, frequently over a period of years, armadillos were caught in this area and offered to the zoo.

At the U. S. Forest Service's District Ranger Office at Meadville we were told of armadillos seen in the vicinity of Hattiesburg in 1936 or 1938.

Alabama.—A gravid female taken at Auburn in the east-central part of the state probably had escaped from captivity (Hardberger, 1950: 177). Kalmbach (*op. cit.*: 7) and Sherman (1936) also mention occurrence of the species in this state. It is not known to us whether these records pertain to an established population, but we have conclusive evidence from Mr. G. M. McLeod of an established colony at Foley, Alabama, in 1949. Mrs. H. S. Peters observed a single animal in 1937. Immediate inquiry established the fact that it had been released there a few weeks before. It is, therefore, safe to assume that the present colony sprang from this lone individual which had to be a gravid female.

Florida.—Bailey (1924) first recorded the establishment of the species in Florida, and Sherman (1936, 1937, and 1943), Kalmbach (1944), Moore (1946) and Pournelle (1950) have traced, in part, the spread of this population. The Florida colony apparently had its origin in a pair brought from Texas to Cocoa, Brevard County, in 1922, by a Mr. Gus Edwards of the latter town. The animals were placed in a private zoo, but soon escaped, and several months later were reported 2½ miles away, at Williams Point. A population became established and thrived in the new habitat, constantly spreading and multiplying. The range extension was slow at first, but gained momentum until during the late thirties and the forties it was rapid. In July, 1948, a questionnaire regarding the local status of the armadillo was mailed to 190 game wardens throughout the state's 67 counties, and more than one hundred replied, providing an idea of the animal's distribution and abundance. These reports indicate that the species has occupied an extensive area along the central east coast, including all of St. Johns, Flagler, Volusia, Seminole, Orange, Brevard, Osceola, Indian River, and St. Lucie counties, and the adjacent parts of Putnam, Lake, Polk, Okeechobee, and Martin counties. In addition, occasional records indicate the presence of the species, in sparse populations, scattered small colonies, or lone individuals, in numerous other parts of the state, including Nassau, Hamilton, Alachua, Marion, Sumter, Pasco, Manatee, Hardee, De Soto, Lee, Hendry, Palm Beach, and Broward counties. In some of these instances reports may be based on individuals or colonies established after transportation and release by humans. In many other instances outlying records probably represent the tentacular outer fringes of the main population, which has tended to follow stream or lake margins in extending its range. The armadillo has spread across the Florida peninsula and has reached the west coast, at least in Lee County near Ft. Myers Beach; the southern tip is the only extensive area which it apparently has not yet reached. There are no records either from the non-peninsula northwestern portion of the state along the Gulf Coast from Escambia County on the west to Madison and Levy counties on the east.

Georgia.—An Atlanta newspaper in early September, 1947, carried an account of an armadillo found and captured by a Mr. McEwen in his yard at Decatur. This animal probably had been brought from elsewhere. If the species has not already established itself in the fauna of southern Georgia, it may be expected to do so within the next few years. As long ago as 1942 the Florida population had extended its range to Starke, within 30 miles of the southern tip of Georgia.

EFFECT OF CLIMATIC FACTORS

Several authors have mentioned the limiting effect of cold and dry weather on armadillos. Kalmbach (*op. cit.*: 7) cites instances of dead ones found in cold weather or drought, and of the disappearance of the population in Borden County, Texas, during a severe storm.

In January and February, 1948, in western Louisiana, unusually low temperatures were experienced (5° to 10° F., or even lower) and freezing temperatures continued for as much as three weeks. On February 3, at the National Red Dirt Game Management Area, Natchitoches Parish, a dead armadillo was found in a hunched position on a thick layer of pine needles. The stomach was empty, but the caecum contained a mass of digested food. Mr. Herbert Muntz of Pollock, Grant Parish, told us that he and his son had found three animals dead on his land during the period of freezing weather. All had died away from protective

cover. In Beauregard Parish, Mrs. C. J. Robinson reported seeing at least nine dead ones on her farm during the same cold spell, and Mr. Ed Pruitt noticed the odor of decaying flesh about many of their burrows after the weather moderated. In Rapides Parish, Mr. W. S. Rolling told of seeing many dead ones during the cold weather ". . . as many as three in one brier patch."

During and just after the cold spell in January 1948, armadillos seen were in poor condition and noticeably sluggish. Those captured for marking in February were easily run down and netted, but in late spring some of these same individuals outran or outdodged the collector. A female caught on February 19 weighed 6¼ pounds; when recaptured three weeks later it weighed 7 pounds.

Almost all persons interviewed in Louisiana agreed that there had been a great reduction in numbers as a result of the 1948 freeze. On the basis of general impression, the reduction through winter mortality was estimated at perhaps 80 per cent. During the late winter and spring following this cold weather, intensive hunting was necessary to obtain sufficient numbers for monthly food samples. During the previous summer and fall such animals had been obtained with no special effort in the course of other routine field work. Armadillos continued to be comparatively scarce until the summer of 1950 when they began to appear in greater numbers.

BREEDING

Published accounts indicate that the armadillo breeds during July, with implantation delayed until November, and a subsequent embryonic development of 120 days. During the present study 13 females were dissected, one in February, five in March, three in April, two in May, and two in June. Of these only one (examined on April 21) contained embryos, and none of the females were lactating or had recently given birth to young.

NUMBERS AND MOVEMENTS

Only meager published information is available to indicate the population density of armadillos in any definite area, or the extent of movements during daily foraging and from season to season. Kalmbach (*op. cit.*: 8) mentions some population figures for Texas, based on estimates and counts. These ranged from .02 to .82 per acre.

Taylor (1946: 273) recorded that in 1945 in Kerr County, central Texas, armadillos were unusually abundant, and estimated the population to be near one per acre. This estimate was based on strip counts of "active" dens, one den often having several openings.

At Weldon, Texas, in July 1947, Goodrum counted 75 holes on a 110-acre pasture, from which he estimated about 30 armadillos to be present.

Near Many, Louisiana, we were told by C. B. Funderburk of an instance in September 1947 of two men killing 17 armadillos from an automobile in two hours.

Taber (1945: 217–219) recorded, from the excavation of dens, 8.5 dens per animal in the Texas coastal prairies, and 4.5 per animal on a ranch in Brazos County. He mentioned movements to higher and drier terrain during wet weather and to streams during the dry season; also the daily movement away from thickets and out into open pastures under cover of darkness. He did not indicate the distances involved for individuals.

Mr. Colon Russell, Federal Game Warden on the Kisatchie National Forest, related his first experience with an armadillo, near Cypress, Louisiana, during a snowstorm in 1926. He was puzzled by the animal's strange tracks and followed them for a mile and a half. Mr. I. E. Bennett, director of the Livingston Park Zoo at Jackson, Mississippi, related an instance of one presented to the zoo which was released one evening in woods a few miles from town. Early the following morning an armadillo, evidently the same, was reported digging in a garden two miles from the point of release. Presumably these represent animals in unfamiliar surroundings, wandering more widely than do individuals with established dens and home ranges.

To obtain some further information on population densities and normal movements, a square 50-acre plot was laid off on the National Red Dirt Game Management Area, Natch-

itoches Parish, Louisiana, at a deserted farm site where armadillos had been noticed frequently. Habitat features, including piles of old boards, remains of collapsed buildings, fence rows with thicket hedges of blackberry, and small fallow fields with thick grass and brush, adjoining oak and pine woods, offered a variety of food and shelter.

Beginning on February 3, 1948, an attempt was made to capture and mark for future recognition all the armadillos on this study area. The animals were taken in a hand net; numbers were made on the carapace with thick red enamel paint to serve for sight records, and numbered, metal tags were attached to their ears. Both methods of marking proved satisfactory for the 4½ months duration of the study, but the painted numbers served for recognition in a number of instances when the animal could not be caught.

Up to the end of May the area was visited two or more times weekly, usually in late afternoon. Parts of several nights were spent on the area. During February, March, April, May, and June, 13 different animals were recorded on the area a total of 32 times. Six were recorded only once each. However, three of these were recorded February 3, 3, and 16, respectively, during or just after freezing weather which was known to have reduced the population of armadillos, and these three may have succumbed. Three others not seen before were taken on the last two visits (May 19, June 14, June 14, respectively). These three might have moved into the area from elsewhere, or they might have escaped notice previously since all were taken at the extreme edge of the study area.

The remaining seven were each recorded two or more times. The most records were obtained for Number 4, male, as follows: February, 3, marked; April, 21, 140 feet E; May, 2, 220 feet E; May, 10, 850 feet NNE; May, 19, (5:40 P.M.) 400 feet N; May, 19, (6:30 P. M.) 640 feet SE; June, 14, 1175 feet N. Thus, there were seven captures in 132 days, within a 1650-foot diameter.

For each of the other six, records were fewer; for Number 7, female, four captures one month within a 690-foot diameter; for Number 9, female, two captures in four days within a 600-foot diameter; for Number 10, female, five captures in 119 days, within a 1100-foot diameter; for Number 11, female, four captures in 46 days within a 550-foot diameter; for Number 12, male, two records the same afternoon, within a 400-foot diameter; for Number 13, male, two records in 27 days, within a 350-foot diameter.

Many records would be necessary to show the general extent of the home range of any one individual. For the animal with most records, Number 4, the most remote points of capture, 1650 feet apart, may have been at opposite extremes of the home range. If so, and if the area covered tends toward a circular shape, the home range of this animal would be approximately 49 acres. For the other individuals, sizes of home ranges calculated were smaller, somewhat in proportion to the fewer records available for each. A usual home range size somewhere in the neighborhood of 50 acres is in line with the impression gained from experience in hunting these animals. Homeward dashes of armadillos, wounded or severely alarmed while foraging, were for distances up to several hundred yards. Such dashes ended at burrow systems showing evidence of regular occupancy, and the animals obviously had their positions well in mind. One, chased often, bolted directly away from the source of alarm at first, but soon swerved or made a sharp turn, when it could safely do so, in order to regain the shelter of its burrow.

Of the 13 armadillos recorded on the 50-acre study area, several were known to range extensively outside its limits. Probably all did so to some extent. Assuming a normal home range to be a 50-acre circle, and plotting individual ranges from each animal's apparent center of activity, it was found that nearly half the aggregate home ranges lay outside the study area. Therefore a maximum population density of about one animal to seven acres is indicated. Judging from the abundance of sign on this area, in relation to others, the figure is well above the average for the Kisatchie National Forest, and other parts of west-central Louisiana. A count of the open holes evidently made by armadillos, on the 50-acre study area, totaled 108, indicating at least 15 per animal. The majority of these were old ones probably used only occasionally as temporary escape shelters.

HABITAT AND GENERAL HABITS

Field work in the present study was concentrated in the longleaf pine type of west-central Louisiana. Within this general type armadillos were collected in a variety of ecologic situations. Of 89 collected, for which habitat notes were taken, 48 were along small stream bottoms in thick woods of sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda*), southern magnolia (*Magnolia grandiflora*), beech (*Fagus* sp.), and various oaks; 14 were in upland woods of pine (*P. palustris*, *P. taeda*, and *P. echinata*) and blackjack oak (*Quercus marilandica*); 10 were in mixed oak woods; 8 were on dry sandy ridges where sandjack oak (*Q. incana*) was dominant; 5 were on grassy hillsides of cutover longleaf pine; and 4 were in meadows of closely grazed old fields surrounded by woods. The deciduous woods along stream bottoms evidently provide the preferred habitat in this part of the range; both the armadillo and its sign were encountered more frequently there than elsewhere.

Cut stream banks are favorite sites for the burrows, especially where large trees are partly undermined, so that the tangle of roots protects and conceals the entrance. Some burrows are in open situations, and enter nearly horizontal ground at a steep angle. Such entrances are often choked with dead leaves through which the animals force their way in or out.

During winter armadillos were often seen foraging out in the sunshine during the middle of the day. At other times of year they are more nocturnal. Few were seen at any season during the morning hours. After mid-afternoon those living in well-shaded situations are apt to be active. During the hottest weather emergence is delayed until evening.

In foraging, the animal moves with a slow, shuffling gait, a few steps at a time, continually digging and probing into the surface litter in search of food. The concentration and rapid jerky movements with which it searches out and devours the prey are somewhat reminiscent of the behavior of a mole.

The sense of hearing is fairly acute. Where there are dry leaves on the ground, an armadillo is apt to become aware of a person's footsteps at distances of 100 feet, despite the commotion caused by its own movements. The animal may become uneasy and interrupt its foraging to hurry away at a rapid walk, breaking into a heavy lope in exposed situations. At other times, under favorable conditions, a person may approach within a few feet of an armadillo without alarming it. But, if air movement is toward the armadillo a person may be scented at a considerable distance. The animal will then stop its activities, rise upon its haunches, and sniff for several seconds. It may move away and either seek concealment or resume foraging with nervous and suspicious actions, making repeated attempts to determine the position and nature of possible danger. At slight alarm an armadillo is apt to try to hide in a convenient shelter, often one that offers little concealment or protection, such as a shallow hole or the space beneath a log. In such situations it often can be caught by the tail which may protrude in plain view. Its powerful forelegs and claws enable it to hold fast when its body is only part way in the hole.

FOOD HABITS

The food habits of the armadillo in Texas have been thoroughly investigated by Kalmbach, but are still the subject of some controversy. While arthropods make up the greater part of the food, the animal is known to eat eggs (including those of game birds), small reptiles and amphibians, and some plant material, including cultivated crops in certain instances.

The present study of food habits is intended merely to supplement Kalmbach's; our analysis was less detailed and our material was less extensive, being limited to one small part of the range, of fairly uniform habitat type, the longleaf pine lands of west-central Louisiana. One hundred and three stomachs were collected in Vernon and Natchitoches parishes; 75 of these were taken in the National Red Dirt Wildlife Management Area of the Kisatchie National Forest, an area of 36,000 acres. A single stomach from Zavalla, Texas, also in the longleaf pine belt, brings the total to 104.

Distribution of the stomachs collected by months was as follows: January—1; February—4; March—14; April—9; May—8; June—8; July—11; August—8; September—5; October—19; November—5; December—11. Most of the armadillos were collected with a .22 caliber pistol. The stomachs of a few found dead on roads were salvaged. All but four stomachs collected were from adults or animals of nearly adult size. Except for those collected in July and August, nearly all stomachs were weighed. For those taken from August through February, the weight recorded was that of the stomach plus its contents. For March through June samples, stomach contents were weighed separately. The average weight of the stomach itself in 30 fresh adult specimens was 42 grams, and on this basis the weight of contents for the earlier collections was estimated, ranging from less than a gram to 168 grams and averaging approximately 50 grams. Food removed from stomachs was preserved in 10 per cent formalin, and was rinsed in running water in a gauze-covered jar, and placed under water in a wide-bottom metal pan for analysis. Items were counted and sorted in separate piles. The relative bulk of each kind of food was estimated as a percentage of the total. From these figures, and from the stomach weights, the weight of each kind of food was computed.

Since the study was not primarily entomological, no reference collection was at hand, and since the material to be analyzed embraced a countless array of insect species, often in fragmentary condition, no attempt was made to identify species or genera of insects. They were merely classified according to family or sometimes to order. For practical purposes these original groupings were combined further, as set forth in Table 1. The total combined samples weighed or computed amounted to 5.13 kg., distributed seasonally about as follows: winter, 16 stomachs, 968 gms.; spring, 31 stomachs, 1480 gms.; summer, 27 stomachs, 1292 gms.; fall, 29 stomachs, 1390 gms. Thus, four fairly well balanced seasonal samples were available.

The seasonal trends are not striking. Beetles, the principal food, seem to be more important in summer and fall than in winter and spring. Moths, butterflies, and dipterous flies (mostly in their larval or pupal stages) appeared much more frequently in the spring sample than in those for other seasons. Reptiles and grasshoppers were mainly in the winter sample—perhaps such agile prey is not easily caught except when partly or wholly dormant. Plant food is a fairly important component of the diet throughout the year, especially in fall, in our sample at least.

The importance of the different types of food is brought out by their listing, in order of relative frequency of occurrence, in the 104 stomachs: adult beetles in 97, larvae of scarabeid beetles in 89, millipedes and centipedes each in 87, ants in 76, "wireworm" beetle larvae in 74, Lepidoptera in 61, spiders in 52, grasshoppers in 46, fruit in 44, Diptera in 40, earthworms in 35, termites in 30, camel crickets in 26, snails in 25, crickets in 19, cockroaches in 16, amphibians in 15 (frogs or toads in 4, salamanders in 12), and other foods each in 10 stomachs or fewer.

Beetles made up the most important element of the diet at all seasons, adults being consumed somewhat less than the larvae. Those taken varied from the largest kinds two inches or more in length down to species of hardly more than microscopic size. Large scarabs such as "June beetles" and related forms make up the greater portion of the adult beetles taken. The large, thick-bodied larvae of these or similar kinds of scarabs were even more important food, often making up more than half of the contents of individual stomachs and sometimes up to 98 per cent. They comprised 31 per cent of the entire food sample, much exceeding in bulk any other one kind of food. "Wireworms," the slender-bodied larvae of tenebrionids and certain other beetles, were high in frequency of occurrence, but made up only 2.1 per cent of the food sample.

Ants occurred in 76 stomachs. The many kinds were mostly minute and too numerous to be counted individually, as often thousands occurred in a stomach. Other Hymenoptera, principally wasps and their grubs, made up hardly more than a trace of the total food sample.

Lepidoptera taken were almost all larvae and pupae and were of many kinds. A few of the larger kinds made up most of the 4.7 per cent accounted for by this Order.

Orthoptera taken consisted principally (6.3 per cent) of short horned grasshoppers of many kinds, with occasional katydids (.5 per cent), camel crickets (1.0 per cent), mole

TABLE 1.—*Seasonal percentage composition of contents of 104 armadillo stomachs*

FOOD ITEM	PERCENTAGE			
	Winter	Spring	Summer	Fall
Insect				
Beetle, larvae and adults (Coleoptera)	24.7	33.6	55.9	56.0
Grasshopper and katydid (Locustidae and Phaneropterinae)	18.5	2.2	3.4	6.0
Crickets (Gryllotalpinae, Oecanthinae, Gryllinae, Rhaphidophorinae)	2.3	.9	2.1	1.6
Cockroach (Blattidae)	.4	.2	.5	.1
Walking stick (Phasmatidae)	3.3	—	.6	.6
Moths and butterflies (Lepidoptera)	1.5	10.8	1.4	3.2
Flies (Diptera)	1.7	12.1	1.0	.1
Ant (Formicidae)	3.7	4.8	5.0	1.6
Wasp (Vespidae)	.4	.2	.8	.1
Termite (Isoptera)	.5	1.5	1.7	.7
Bug (Hemiptera)	3.6	T	—	.1
Neuroptera	—	—	.1	—
Cicada (Cicadidae)	T	.4	—	—
Earwig (Dermaptera)	—	T	—	—
Other Arthropod				
Spider (Araneida)	1.9	2.7	1.3	2.3
Harvestman (Phalangida)	—	—	.2	.1
Scorpion (Scorpionidae)	.2	.1	.2	—
Crayfish	—	—	3.9	—
Sow bug	—	.1	—	T
Centipede (Chilopoda)	3.8	2.5	1.7	1.9
Millipede (Diplopoda)	8.7	4.8	3.6	7.3
Miscellaneous Invertebrate				
Snail and slug	2.2	1.4	2.6	.2
Earthworm	1.3	9.7	1.1	2.7
Vertebrate				
Amphibian	1.4	.7	.5	1.6
Reptile	11.8	.1	.3	.6
Reptile egg	—	1.4	2.2	—
Plant	8.1	9.8	9.9	13.2

crickets and other crickets (.7 per cent), and cockroaches. Numerous walking sticks (Phasmatidae) were recorded during summer and fall.

Diptera taken were almost entirely larvae including a number of large fleshy kinds, and large numbers of "leatherjackets" (3.0 per cent). Hemiptera taken were mostly large kinds, but were not numerous.

Arachnida included many kinds of spiders, mainly lycosids. Large, hairy spiders, popularly known as tarantulas, were found in six stomachs and made up .6 per cent. Scorpions were found in four stomachs, harvestmen in five.

Centipedes and millipedes comprised small (2.4 and 6.1 per cent) parts of the diet, but the frequency of occurrence was high for each. Many kinds of each were represented.

Earthworms made up 4.1 per cent. Slugs and snails made up 1.3 per cent.

Frogs and toads (.4 per cent) found in four stomachs were all small ones too far digested to be identified. The 16 salamanders found in 12 stomachs were mostly minute ones (*Manculus*, etc.), but included one *Amphiuma*. A total of 23 lizards (1.9 per cent) recorded included the tail only of one five-lined skink (*Eumeces fasciatus*), seven brown skinks (*Scincella laterale*), one consisting of only a broken tail, 14 anoles (*Anolis carolinensis*), and one six-lined racerunner (*Cnemidophorus sexlineatus*). Eggs of lizards were found during May, June, July, and August in 12 stomachs. Apparently in most instances these were eggs of the anole, but they may have included some of *Eumeces*, *Sceloporus* and *Cnemidophorus*. Larger reptile eggs evidently of a snake, and estimated to have been 40 mm. long, were found in one stomach taken in May. Reptile eggs were computed as 1.0 per cent of the food. Three small snakes (2 *Haldea striatula*, 1 unidentifiable) were recorded.

The plant food consisted of fleshy fruits, seeds, and mushrooms. Four instances of feeding on fruits of the white bay (*Magnolia virginiana*) were recorded in August and October. Three instances of feeding on muscadine grape (*Muscadinia rotundifolia*) were recorded in August and September.

Four stomachs collected in May and one in June contained blueberries (*Vaccinium* sp.). One June stomach contained 54 dewberries (*Rubus trivialis*) which made up half its contents. Mushrooms were found in three stomachs taken in June and one taken in August. Many stomachs, particularly those taken in fall and winter, contained pulpy disintegrating skin of fruits which were not definitely identified. In one stomach taken in November the contents consisted of approximately half longleaf pine (*Pinus palustris*) seeds. This was just after the beginning of seed fall. Another stomach collected at this same time and place contained a small quantity of longleaf pine seeds.

In general, the trends resemble those revealed in Kalmbach's earlier study of the armadillo in Texas. Presumably the differences are due primarily to the different geographic origins of the samples, and are also influenced somewhat by different seasonal distributions. Kalmbach's material originated over a wide area in central and eastern Texas, under diverse ecological conditions, and slightly more than 77 per cent of the 169 stomachs used for detailed analysis were from the season May–June–July. The 104 stomachs used in our sample were more evenly distributed seasonally. To a lesser extent, differences in techniques of analysis, and of handling the data obtained, may have influenced the figures. In Kalmbach's study each stomach was given equal valence as a separate entity in computing percentages of food items, whereas in the present study, the percentage figures pertain to the pooled total of all recorded food items. For several classes of prey the percentages of the totals obtained by these different methods in the two studies were similar, as shown by the following sets of figures, the first of each pair from Kalmbach (*op. cit.*, p. 32) and the second from our own analysis: Coleoptera, 41.6–44.6; Lepidoptera, 7.8–4.7; Orthoptera, 6.2–8.5; Hemiptera, 2.0–1.6; Myriapoda, 6.2–8.5; Arachnida, 1.7–2.1; miscellaneous invertebrates, 6.2–6.4. Notable differences in percentages occurred in the remaining classes of food: Hymenoptera, 14.0–3.9; Isoptera, 4.5–1.2; Diptera, 1.5–4.2; Amphibia and Reptilia combined, 1.2–4.5; other vertebrates, .4–none; fruits, berries, seeds, and fungi combined, 2.1–9.8; vegetable debris, 4.6–not recorded.

The vegetable component of the diet was considerably greater in our own study; nearly half the stomachs (48) contained plant food. Even more extensive use of plant food was recorded by Hamilton (1946: 175) who found that during August 1942, north of San Antonio, Texas, the black persimmon (*Diospyros texana*) was a favorite food, apparently accounting for more than 80 per cent of the stomach contents.

ECONOMIC BEARING

Being abundant and widespread, the armadillo affects human interests both beneficially and detrimentally. Without presuming to render any final judgment on the animal's economic status we present the following list of its effects on human welfare, as brought to our attention during the course of the present study.

BENEFICIAL EFFECTS

Destruction of insect pests.—The most important effect of the armadillo appears to be predation on arthropods, preponderantly noxious kinds. Scarabeid beetles, comprising the one most important food source are highly injurious to plant life. Many kinds spend their long larval development feeding on the roots of living plants. In view of the enormous quantities of insects required to support a single armadillo, and the abundance of these relatively large entomophagous mammals, the probable total of such destruction is impressive indeed. Even so, it may be questioned whether the armadillo exerts appreciable biological control. In Angelina County, Texas, a possible example of such control was related by the county agent, Mr. O. C. La Grove. He stated that a certain 50-acre corn and cane field had been overrun yearly by cane beetles until armadillos became established. Depredations of the cane beetles then ceased and armadillos were known to have preyed upon them extensively.

Destruction of insectivorous prey, the spiders, scorpions, centipedes, small lizards, and amphibians, may partly offset the armadillo's beneficial insect-eating activities. However, as nearly all these forms are generally regarded with disfavor by the public the armadillo may be credited with a useful function in destroying them. The Texas Game, Fish, and Oyster Commission (1945: 136) indicates that the presence of armadillos may be beneficial to quail (despite their occasional predation on eggs) as: "Some species of ants destroy quail eggs at pipping time. Since the armadillo feeds upon these ants, it is likely that they do more good than harm. . . ."

Destruction of dangerous snakes.—Many times, at localities where the animal has become abundant in Louisiana, the statement was made by long-time residents that, due to armadillo predation, snakes were much less common than they were 20 years or more ago. The relations of the armadillo to trends in reptile populations is a subject worthy of further study. However, it seems doubtful whether the observed reduction in numbers of snakes can be credited primarily to the armadillo. In the stomach analyses, reptiles found were mostly lizards and included only the smallest kinds of snakes. Through destruction of their eggs the animal may limit the reproduction of certain kinds, but in only one instance were reptile eggs larger than those of small lizards found in a stomach. Such active, fairly large, and viviparous kinds as the venomous water moccasin (*Agkistrodon piscivorous*), rattlesnake (*Crotalus horridus*), and the non-venomous fish-eating water snakes (*Natrix* sp.) do not seem vulnerable to armadillo predation. Their reduction in numbers may more logically be attributed to deforestation, fire, and increase in the human population.

Use of burrows by other wildlife.—In its chosen habitat the armadillo ordinarily greatly exceeds in numbers other wildlife species of comparable size. Its burrows improve habitat conditions for some kinds, including valuable fur bearers, by providing shelter. Taber (1945: 225) recorded finding five opossums, five cottontails, four cotton rats, one skunk, two burrowing owls, and six armadillos in a series of 50 burrows excavated in Chambers County, Texas. He mentions that in several instances mink and skunks have been known to inhabit armadillo dens.

Source of food for humans.—As reported by Kalmbach (*op. cit.*: 54) and others, the Texas armadillo is extensively used for food by humans, particularly rural people and those with meager incomes. In the southeastern states the animal's edible qualities seem to be almost unknown. Many of the persons interviewed, including some who considered raccoon and 'possum legitimate game, expressed revulsion at the idea of eating an armadillo, prejudiced

by the bizarre appearance and peculiar smell of the animal, and its vernacular name of "gravedigger." If the fact that the armadillo is suitable for food and is used as such elsewhere were more generally known in Louisiana, it might in time come to assume a position of importance as a food or "game" animal.

Basis of curio trade.—Kalmbach (*op. cit.:* 54) describes the Texas curio trade in armadillo baskets and other objects made from the polished shells of these animals. This industry reached a peak prior to the first World War and is still thriving on a reduced scale. No instance of such use was found by us in the states east of Texas.

Forest influence.—Aside from their destruction of insect life, armadillos play an important part in the ecology of forest and range lands through their digging activity. In bottomlands much of their activity is directed to tearing up rotten logs to get at the abundant arthropod life within. Disintegration of dead wood and its incorporation in the soil is thereby hastened, and soil layers are mixed. Quantities of organic material are carried underground for nesting material. The layer of surface litter, leaves, and twigs beneath tree canopies, and the mat of dead grass in more open country, is penetrated, broken, and covered over by the armadillo's digging. Certain types of plants, notably legumes, are favored by this disturbance of the soil surface. Stoddard (1946: 355) has described similar activity by hogs as partly beneficial to bobwhite quail: "Such rooting of the grass-bound land is at times almost the equivalent of plowing, in that favorable vegetation such as clovers, beggarweeds, and partridge peas replaces the uprooted grasses. Open spots . . . may also create favorable nesting sites . . . may be frequented by quail in search for pine 'mast' and sweetgum seeds, which otherwise would be unavailable to them." Rooting, scratching, and probing by armadillos would seem to have similar beneficial effect though perhaps on a smaller scale.

HARMFUL EFFECTS

Destruction of quail eggs.—Among sportsmen in the region occupied by the armadillo, there are frequent complaints that the animal destroys quail nests and therefore is responsible for observed reductions in quail populations, but supporting evidence is still meager. In Kalmbach's study special attention was directed toward this relationship, and 112 of the 281 stomachs were collected in May and June, the quail-nesting season. Yet only one definite instance of feeding on quail eggs was recorded, and the nest raided might have been one of a series of artificial nests "planted" where most likely to be found by armadillos. Four of the 281 stomachs contained bird eggs—in one instance a chicken egg "planted" near a den, and in three instances fragments not definitely identified. None of the 104 stomachs in the present study contained bird eggs. Baker (1943: 379) found no eggs in 25 stomachs collected in May in eastern Texas. We were told of one instance of an armadillo confined in a propagating enclosure with nesting quail without any damage resulting.

On the other hand Mr. Tom Beasley, Natchitoches Parish, Louisiana, told us of finding an armadillo in the act of robbing a quail nest near his house. Mr. Ed Pruitt of Beauregard Parish claimed he had often seen nests of quail and cottontail recently destroyed by these animals. An observation of armadillo predation on young cottontails is recorded by Newman and Baker (1942). Whether the armadillo is at times one of the major quail predators, or whether it might affect the trend of quail populations is doubtful. The abundance and distribution of armadillo probings and scratchings where it is numerous suggest that it might cover such areas rather thoroughly during the nesting period of quail, and if the eggs are a particularly attractive food, a substantial proportion of the nests present might be found and robbed by it.

Destruction of domestic poultry.—The larger eggs of domestic fowls are less easily broken, and apparently are less apt to be taken, by the armadillo than are the small eggs of quail. Kalmbach (*op. cit.:* 48) states that the trait of feeding on hen's eggs may be individually learned and that old individuals, particularly males, are more adept than others. ". . . there is acceptable testimony that armadillos raid poultry houses. . . . Once an armadillo becomes

aware of an available supply of hen's eggs in unprotected nests there is reason to believe that it will arrange its evening feeding route to visit them."

A number of apparently authentic instances were related to us, and we gained the impression that where armadillos are common they are liable to be among the most frequent predators on chicken eggs. Two informants told of predation on Guinea fowl nests, and one told of predation on nests of domestic ducks. In one instance related to us, the owner was aroused by the commotion in his chicken house and saw an armadillo chasing a chicken. Another person discovered an armadillo in a chicken yard carrying in its mouth a young chick, which evidently it had killed. One person reported armadillos breaking glass eggs in chicken nests.

Damage by burrowing.—In isolated instances armadillos have done damage by digging into river levees and dikes of canals. Taber (1945: 216) stated that early stages of gully erosion sometimes begin at armadillo dens in exposed situations. The animals are apt to take up quarters beneath buildings, and may undermine the foundations and fireplace chimneys by their digging, causing considerable danger. Like the badger, the armadillo incurs the dislike of horsemen, whose mounts are liable to stumble in its holes. Y. W. Hatton, at Olla, Louisiana, complained that armadillos had been troublesome there by making holes under fences, which later enlarged to allow free-ranging hogs access to the fenced lands where they might damage crops or pine trees.

Damage to crops.—It is generally agreed by farmers in armadillo country that the animals are destructive to cantaloupes and peanuts, and, at times, to other crops. Several specific instances have come to our attention, in Vernon, Allen, Natchitoches, Rapides, Winn, and Beauregard parishes. Six informants told of armadillo depredations on cantaloupes (in one case involving destruction of the entire crop); four complained of depredations on watermelons, two of depredations on peanuts, one of damage to tomatoes, one of their breaking down cornstalks, and one of their uprooting lespedeza hay. In some of the instances the armadillos may have been searching for injurious insects, the destruction of which partly compensated for their harm to crops.

Competition with hogs.—Mr. Walter Hopkins of the Southern Forest Experiment Station, U. S. Forest Service, studying the economics of free ranging hogs in forests of central Louisiana, talked with several owners who thought that armadillos offered serious competition to hogs for animal food. Such competition might occur in summer when hogs are in poorest condition due to drought and seasonal protein deficiency in the plant foods available to them. Six hog stomachs collected on the Kisatchie National Forest of central Louisiana in September, October, November, February, and March, had only traces of animal food—small salamanders, earthworms, beetles, and larvae. Where armadillos and free ranging hogs are both abundant, as they are through much of the forest land in Louisiana, they often feed upon each other's carcasses, available as highway casualties or otherwise. Under such circumstances the armadillo might be a carrier of trichinosis, but this relationship has not yet been demonstrated.

Destruction of pine seed.—In cold weather of late fall and early winter, when insects are scarce, numerous wildlife species which are primarily insectivorous turn to pine seeds as an abundant and nutritious substitute. Their combined effect has been sufficient to nullify direct seeding operations in most instances where reforestation has been attempted by this method in the southeastern states. We obtained evidence that the armadillo, like many other primarily insectivorous forms, may at times take pine seeds. In one stomach examined, longleaf pine seeds had been the principal item of a meal, and in a second, a small quantity of the same kind of seed was present. Individual armadillos might occasionally do some damage by eating quantities of pine seed.

Interference with hunting and livestock handling.—Where armadillos are abundant they frequently interfere with most forms of game hunting and livestock handling, especially where dogs are used. Young dogs are liable to develop the habit of chasing armadillos which are more easily detected than most other wild animals. Still hunters are often foiled at

making a kill of squirrel or deer when an armadillo alerts their quarry by his noisy activity in the woods.

SUMMARY

The nine-banded armadillo, *Dasypus novemcinctus*, has been steadily extending its range in the United States for the past 70 or 80 years. Originally limited to extreme southern Texas and regions southward, it has invaded most of Texas and Louisiana, and parts of New Mexico, Oklahoma, Arkansas, and Mississippi. Having reached Florida by human agency it has spread over a large part of the state, and there are records of its occurrence in Kansas, Missouri, Alabama, and Georgia.

In Louisiana, wooded bottomlands are the preferred habitat. During protracted periods of freezing weather—as in January 1948 in Louisiana—armadillos die in large numbers, and populations are noticeably reduced.

Only one of 13 females examined in late winter and spring of 1948 was breeding. On a square 50-acre study area where armadillos were captured, marked for future recognition, and then released, indication was obtained that home ranges are limited to radii of a few hundred feet. The individual for which most records were available—seven captures in a 132-day period—was calculated to range over approximately 50 acres. Assuming that this is the typical size of a home range, and that no interchange of ranges with individuals from the outside occurred in the 4½-month period covered by the records, a population figure of about one animal to seven acres was obtained. This is probably well above average for western Louisiana; higher figures have been recorded in the literature (but perhaps with insufficient basis) for various parts of Texas.

In a year-round series of 104 stomachs, mostly from the longleaf pine belt of the Kisatchie National Forest in western Louisiana, beetles and their larvae were the most important food (44.6 per cent), followed by plant food (fruits, berries, seeds, mushrooms, 9.8 per cent); Orthoptera and Myriapoda (each 8.5 per cent); snails, slugs, and earthworms combined (6.4 per cent); Lepidoptera (4.7 per cent); amphibians and reptiles (4.5 per cent); Diptera (4.2 per cent); Hymenoptera, mainly ants (3.9 per cent); Arachnida (2.1 per cent); Hemiptera (1.6 per cent); Isoptera (1.2 per cent). The trend of food composition paralleled that found by Kalmbach in Texas, differing largely in the smaller percentages of ants, termites, and Lepidoptera, and the larger percentages of reptiles and plant food.

Armadillos are beneficial in destroying great quantities of insects and other noxious pests; also, perhaps, in preying upon certain venomous snakes; in providing burrows as shelter for other wildlife, including fur-bearers; in providing material for the curio trade; as a source of human food; and in cultivating and fertilizing the soil.

These beneficial effects are offset, in part at least, by the armadillo's habit of eating eggs (both those of quail and domestic poultry); by destructive undermining of buildings, starting erosion, breaking dikes and levees, digging under fences and allowing hogs entrance to enclosed fields; damaging cultivated crops, especially cantaloupes, watermelons, and peanuts, sometimes tomatoes, and others; and interference with game hunting. There is possibly some competition with range hogs for food. The armadillo is one of the many wildlife species which occasionally eats seed of longleaf pine.

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STUDIES ON THE HELMINTH FAUNA OF ALASKA. V. NOTES ON ADAK RATS (*RATTUS NORVEGICUS* BERKENHOUT) WITH SPECIAL REFERENCE TO HELMINTH PARASITES

By Everett L. Schiller

The rat population of Adak, Aleutian Islands, Alaska, has attained serious proportions in recent years. It is not known when rats were first introduced here, but, according to the Annual Sanitary Report for the Adak Sector for the year 1944, which states, "There are no rodents inhabiting the islands of this subsector. . . . ," they became established sometime after this date.

Heavy economic losses due to rat damage at Army and Navy installations during 1946 prompted the first specific observations. These were made in July, 1947, by Dr. Dale Jenkins, Medical Division, Army Chemical Center. His report indicated that "The brown rat first appeared in 1946 in the dock areas and then spread to food warehouses and other buildings and subsequently became a serious problem." Sporadic but intensive eradication programs and improved methods for waste and garbage collection brought about temporary controls in the immediate installation area. Dr. Jenkins stated that "Under present conditions no serious health problem exists. . . . "

Helminth parasites of rats have been investigated in many parts of the world; however, no previous investigations of the parasites of this host have been made on the Aleutian Islands. Because rats are implicated in the transmission of various diseases to man, a knowledge of rat parasites is fundamental. The purpose of the present study was to obtain information concerning the helminth parasites of Adak rats and to determine, insofar as possible, the occurrence of related health problems. This study was conducted on Adak during May, 1950, in conjunction with animal-borne disease investigations by the Arctic Health Research Center, U. S. Public Health Service, Anchorage, Alaska.

Environmental relationships.—The land mammals of the Aleutian Islands are few and are mainly restricted to the easternmost islands. Only four species of land mammals, all of which have been introduced, occur on Adak. These include the brown rat (*Rattus norvegicus*), the dog, the house cat, and the arctic fox (*Alopex lagopus*). Field observations and intensive trapping over most of the northern part of the island failed to disclose the presence of ground squirrels, microtine rodents, or shrews.

The rats inhabiting Adak are of unusual interest from the standpoint of environmental adaptation. Allan (1936) stated that "The majority of introduced species that maintain themselves, succeed only in the highly modified environment of man or in the impoverished biota of islands. . . . " Rats are probably the best example of an introduced species to which Allan referred. Continental rat infestations succeed largely under the protection of human agriculture and architecture. Rat invasions of the "impoverished biota of islands" are also well known. Adak offers both the "highly modified environment of man" within the limits of the military installations as well as the "impoverished biota" in natural areas more remote from human habitation. Rats are well established under both

of these environmental conditions and demonstrate a gradual transition from one into the other.

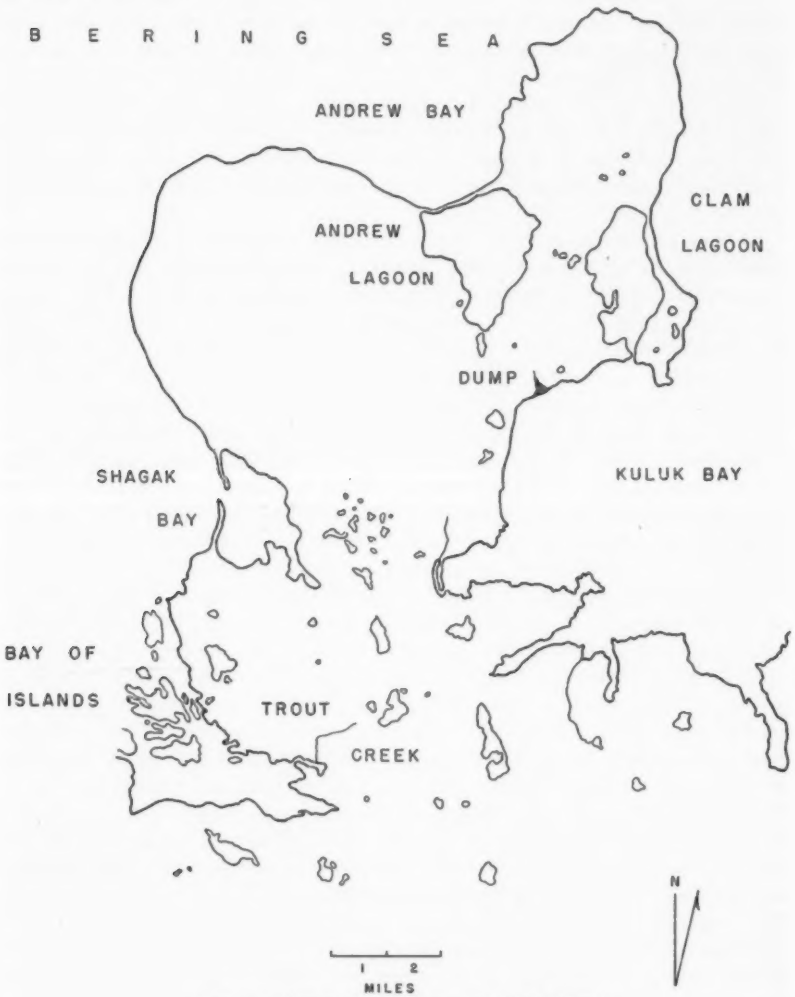

FIG. 1.—Map of northern part of Adak Island

Inadequate food, competition by other species, and predation are some of the principal factors which have been considered biotic limitations preventing the establishment of introduced species. The relative absence of these limitations on the Adak rat population at the edges of concentration areas probably ac-

counts, in part, for their successful transition and adaptation to an existence in a natural environment.

The temperatures of the Aleutian Islands are moderate and fairly uniform, seldom going as low as 0°F except at the extreme eastern end where they occasionally drop to −10°F. Average January temperatures recorded on Adak from 1943 through 1948 ranged from 15°F to 20°F (Climatological Division, Anchorage Weather Bureau; personal communication). Under these relatively mild conditions it is unnecessary for rats to seek the protection of buildings during the winter months. This may be contrasted with the "seasonal migrations" exhibited by rats inhabiting many continental regions where the temperatures are more extreme.

Dumping grounds in the "highly modified environment of man" provide ideal habitats for rats and usually constitute areas of greatest density. In this respect, Adak is no exception. A deep ravine opening into Kuluk Bay, Bering Sea, and located about a mile north of the military base, is utilized for refuse and garbage disposal (Fig. 1). At the time these observations were made, the steep walls of this ravine were honeycombed everywhere with rat burrows to such a degree that one would frequently break through while walking there (Pl. I). Deeply-worn runways, some more than 600 yards in length, extended for considerable distances without any cover, and led to the dump from every direction. "Wet" garbage collected from messing facilities was deposited here several times daily, providing an abundance of food for the resident rats as well as for such visitors as gulls, ravens, dogs, cats, and occasional arctic foxes. The gulls congregated in great numbers during the daytime and constituted the only real competition for food (Pl. I). Being diurnal, the gulls always left before dark, at about the time the rats began foraging. Judging by the amount of food remaining the following morning, the quantity was more than ample.

In the early morning and late evening, several bald eagles (*Haliaetus leucocephalus washingtoni*) were commonly observed in the dump where they perched on the ground at a vantage point near the top of the ravine. Bones and skin fragments of rats contained in some of the regurgitated pellets found near these resting places furnished evidence that rats played no small part in the diet of these birds. The eagles were frequent visitors during the day as well, but perched on poles in the vicinity, always maintaining a safe distance from human activity. Murie (1940), in conducting food habit studies of the northern bald eagle throughout the Aleutian Islands, recorded *Rattus norvegicus* as a food item of this bird. He reports that "Small rodents are not available on most of the islands. Ground squirrels have been introduced on Kavalga Island for fox food and the eagles apparently take full advantage of that supply. . . . House rats are common on Rat Island. Probably on only three other islands could these be found by eagles."

Predation on rats by dogs and cats in this dump was relatively negligible. Cats were few on the island, but they were often observed prowling the dump after dark and occasionally were encountered with a "kill" which they apparently had no desire to eat. Stray dogs probably became ratters by necessity rather than choice. Several were known to kill and eat rats at the installation, but

PLATE I

UPPER: Congregation of gulls in the Adak dump
LOWER: Rat burrows in the side of the ravine

PLATE II

UPPER: Main dump; note body of bus in upper left
LOWER: Dead rats which have accumulated naturally after poisoning

came to the dump primarily to pick over the garbage. Although it is quite probable that the arctic fox accounted for many rats in other parts of the island, they came to the dump only rarely because of its proximity to the military base.

The land-fill method of sanitary control, to which the terrain of the dump was well suited, had been carried out to some degree, but the practice was very lax. The disposal, in the same general place as the food wastes, of large and bulky items which could not be burned, created open areas and protected spaces which greatly reduced the effectiveness of the land-fill system (Pl. II; Note that the wreckage includes such large items of junk as passenger-bus bodies).

Rats were commonly observed during the daytime north of the dump in the region of Clam and Andrew Lagoons, as well as west across the island to Shagak Bay and southwest to the Bay of Islands. They were frequently "flushed" from the luxuriant marsh grass bordering Trout Creek and were seen among the rocks a few feet from the water line along the coast of the Bay of Islands. Rat tracks were numerous in the wet bottom sands of the bay at low tide and their burrows were abundant in the sandy hills a short distance from the shore line. It is apparent that the coastal rats depend largely on the invertebrate inhabitants of the littoral zone, living on prawns, shrimps, and molluscs. Dead fish, vegetation, and insects contribute much to their diet as evidenced by examinations of stomach contents.

Inasmuch as these areas represent habitats remote from the environment modified by man, it is evident that rats, in extending their range from the improved areas, have been successful in their transition and adaptation to a completely independent existence under natural conditions.

The coastal cliffs as well as the inland regions of this treeless island are important nesting grounds for many species of birds. Since rats eat birds' eggs voraciously, and must destroy countless numbers of young birds during the nesting and breeding season, it is apparent that these animals are a serious menace to the avifauna of this island refuge. Endemic species on islands have often succumbed to introduced forms. House rats on Lord Howe Island off the coast of Australia caused the extinction of endemic birds (Hesse, Allee, and Schmidt, 1937, p. 524). Introduced hogs and rats eliminated all the endemic land birds on the South Atlantic island of Tristan da Cunha (Murphy, 1938).

The arctic fox ranges over most of the island. Several were observed near Shagak Bay and their dens were also found in this region. Marine invertebrates are an important food source for these animals also. There is little evidence that the arctic fox feeds to any great extent upon rats, but in consideration of the lack of endemic mammalian food species on the island it is quite probable that rats constitute at least a part of their diet. Judging by their generally stunted bodies and poor hair coats, it is obvious that these animals are not thriving under present conditions on Adak. A definite arrangement has been made to exterminate these animals from this island in the interest of preserving ground-nesting birds and preventing possible damage to the sea otter (*Enhydra lutra*) population. While it is unquestionable that serious destruction of bird life can be attributed to predation by foxes, it is doubtful whether these animals

are as injurious as the rats in this regard. The arctic fox problem is another example, of which there are innumerable instances, of the folly of the willful introduction of exotic species.

TABLE 1.—*Helminth parasites recovered in the examination of 224 Adak rats*

PARASITE	NUMBER OF RATS INFECTED	PER CENT OF RATS INFECTED
Hymenolepis fraterna Stiles, 1906	95	42.4
Taenia taeniaeformis (larvae) (Batsch, 1786)	1	0.4
Trichosomoides crassicauda (Bellingham, 1840)	12	5.4
Syphacia obvelata (Rudolphi, 1802)	7	3.1
Trichinella spiralis (Owen, 1835)	27	12.0

TABLE 2.—*Percentage incidence of infection with Hymenolepis fraterna according to weight group*

WEIGHT GROUP (GRAMS)	RATS COLLECTED	RATS INFECTED	PER CENT INFECTED
0–99	22	4	18.1
100–199	37	11	30.0
200–299	49	21	42.8
300–399	69	34	49.2
400–499	38	19	50.0
500–599	9	6	66.6
Total	224	95	

TABLE 3.—*Percentage incidence of infection with Trichinella spiralis according to weight group based on a three-interval moving average*

WEIGHT GROUP (GRAMS)	RATS COLLECTED	RATS INFECTED	MOVING AVERAGE		
			Collected	Infected	Per cent
101–125	12	0			
126–150	12	0	35	2	5.5
151–175	11	2	26	2	7.6
176–200	3	0	28	7	25.0
201–225	14	5	29	9	31.0
226–250	12	4	38	11	29.0
251–275	12	2	36	10	27.7
276–300	12	4	37	6	16.1
301–325	13	0	43	5	11.6
326–350	18	1	50	3	6.0
351–375	19	2	58	6	10.0
376–400	21	3			

Helminthology.—Most of the 224 rats examined for helminth parasites were collected, either by trapping or poisoning, in the main dump. Poison baits placed at the entrances to rat burrows and in runways along the sides of the

ravine resulted in an abundant surface kill. At death, these animals rolled down the steep slopes of this ravine and collected in sizable numbers against obstructions (Pl. II). Others were trapped in the warehouse and hospital areas of the military base, as well as along Trout Creek and at the Bay of Islands (Fig. 1). It is of interest to note that both spotted and albino rats occurred in this population. Of the total number of rats, 119 were females (104 sexually mature, with perforate vagina) and 105 were males. Eighteen of the females

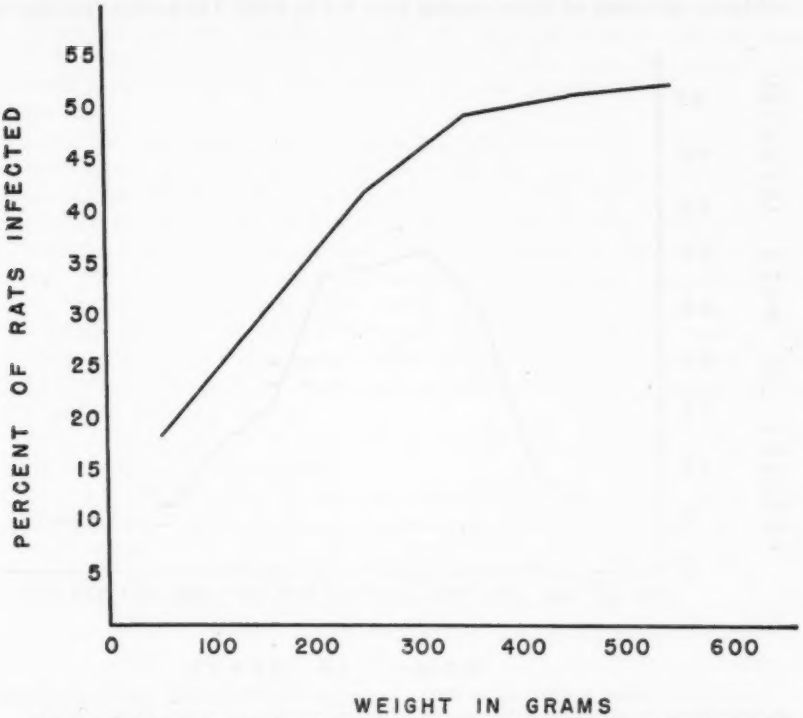

FIG. 2.—Incidence of infection of *Rattus norvegicus* with *Hymenolepis fraterna* according to host weight.

contained embryos (implanted embryos grossly visible in uterine horns at autopsy) ranging in numbers from 5 to 19, with an average of 12 embryos per rat.

The five species of helminths found parasitic in 122 (54 per cent) of the rats examined are shown in Table I. The percentage incidence of infection with *Hymenolepis fraterna* Stiles, 1906, according to 100-gram weight groups, is shown in Table 2 and graphically in Figure 2. It is noted in this series of rats that infection with *H. fraterna* is acquired by a rather high percentage of young rats

(less than 100 grams in weight). The incidence of infection increases with age until approximately one-half of the rats are parasitized by this cestode by the time an average weight of about 350 grams is attained. The relative number of infected rats remains about the same from this point through the older age group.

The methods of examination for *Trichinella spiralis* (Owen, 1835), and the determination of larvae per gram of tissue was the same as the standard procedure for the artificial digestion of tissue as used by Brandly and Rausch (1950). Twenty-seven (12 per cent) of the rats exhibited trichinosis, with the number of larvae per gram of tissue ranging from 0.1 to 1200. The average number of

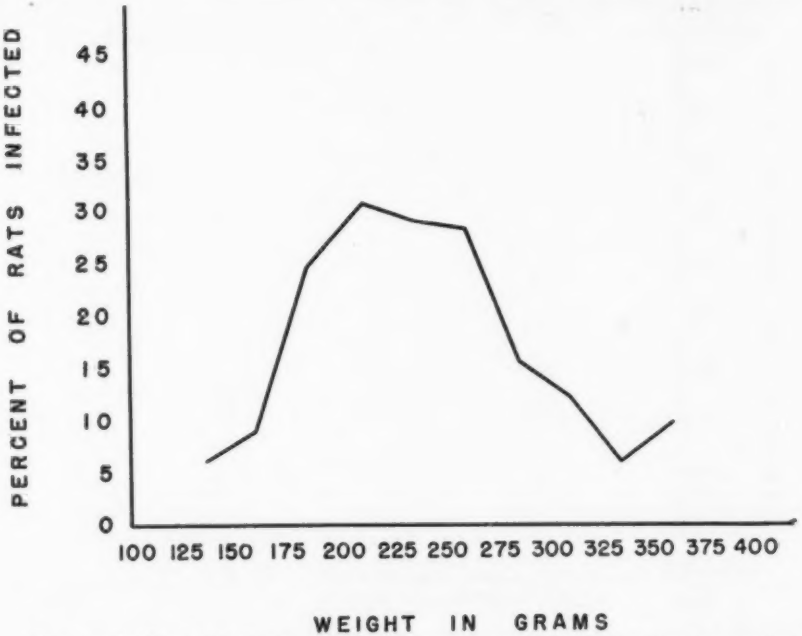

FIG. 3.—Incidence of infection of *Rattus norvegicus* with *Trichinella spiralis* according to host weight.

larvae per gram of tissue per infected rat was 84. Percentage incidence of infection, based on a three-interval moving average with 25 grams per interval, is shown in Table 3 and illustrated graphically in Figure 3. For the present purposes, weight is considered directly proportional to age, since no other criterion is available.

In this sample of rats, it may be seen that infection with *T. spiralis* is first manifested by the presence of encysted larvae when the animals attain a weight of about 125 grams. The incidence of infection increases rapidly with the greatest relative number of infected animals occurring in the 200–275-gram weight

group. After this weight average is reached, there is an abrupt decline in the incidence of infection. In view of the permanent nature of *Trichinella* infection, it is suggested that there may be a high mortality among rats of this age group with the survivors exhibiting a much lower incidence of infection. While there is no evidence that this parasite is directly responsible for such a mortality, it must not be excluded as a possible factor. There is no significant correlation between the numbers of larvae per gram of tissue per infected animal and this peak in incidence of infection with *T. spiralis*.

While there has been no record of illness at Adak due to the transmission of infectious organisms resulting from rat bite, there are several cases on record at the base hospital of soldiers who had been bitten about the ears and face while they were asleep. These injuries were all treated, with an uneventful recovery.

Sixteen dogs, impounded by the military police at Davis Air Base, Adak, were made available for autopsy. Five (31 per cent) were parasitized by nematodes identified as *Toxocara canis* (Werner, 1782). Only one animal was positive for trichinosis, with four larvae per gram of tissue recovered upon artificial digestion. It is noteworthy that no cestodes or trematodes of dogs were encountered in this study. The absence of the essential intermediate hosts on Adak probably precludes much opportunity for cestode parasitism.

Inasmuch as Dr. Jenkins (1947) reported two cases of Weil's disease in dogs from Adak, an effort was made to find additional evidence for the presence of leptospirosis. At autopsy, there was no grossly visible manifestation of this disease in either rats or dogs.

Only one cat could be obtained for examination; this animal was found negative for helminth parasites.

Two adult arctic foxes (1 male and 1 female) were collected, primarily to try to determine whether trichinosis existed in this host on the island. One animal was positive for *T. spiralis* with 43 larvae per gram of tissue. Söntgen (1939) reported that the infection of red foxes with *Trichinella* resulted from consumption of the skinned carcasses of other red foxes. Whether the foxes on Adak become infected through cannibalism or through eating infected rats is unknown. Both animals harbored intestinal nematodes identified as *Toxascaris leonina* (von Linstow, 1902).

Because of the relationship displayed by the bald eagle to the inhabitants of the dump, two adult birds were acquired for examination. Both were negative for trichinosis, upon digestion. The small intestine of each bird contained specimens of acanthocephala which were determined by Dr. H. J. Van Cleave as "immature juveniles of the genus *Corynosoma*." Dr. Van Cleave's comments (personal communication) relative to the status of these worms in the bald eagle are of especial interest. He stated that "More than likely the eagle received these worms from the body of a fish, which acting as an intermediate host, had become infected through eating arthropods, the first larval host. It is extremely doubtful if the eagle could serve as a normal definitive host to bring the worms to full maturity. In other words, within the body of the eagle the acanthocephala

had reached a dead end, tangential to the normal life cycle." He further remarks that "There is a possibility that two distinct species might be represented but specific identification of immature individuals in this genus is difficult if not impossible. The status of the mature individuals of the genus is still in a somewhat uncertain state because of the extreme individual variation and unsatisfactory descriptions of species previously recognized."

Discussion.—Aside from the extensive economic losses already attributed to Adak rats, the potential, if not actual, health menace represented by the existence of this population of unusual density must be recognized. The successful establishment of rats here under natural conditions creates a difficult problem. It is obvious that complete eradication is nearly impossible. Control of rats in the improved areas is essentially a matter of the intensive application of well-established rodent-control practices. The writer was informed that the Navy sanitarians responsible for rodent control at their station were trapping "50 to 60 rats a week." A study of reproductive rates in wild rat populations has been presented by Emlen and Davis (1948). In applying their formulae for determining the average frequency of pregnancy and birth rate to a series of rats autopsied in their Baltimore study, it was calculated that an average adult female had one litter every 65 days and produced 30 young during the 218-day sampling period. Although no attempt was made during the present study to gain specific information relative to reproductive rates in the Adak rat population, the observations concerning pregnancy presented earlier in this paper, in view of the above findings, serve to emphasize the futility of a limited trapping program as the single rat-control measure. Emphasis must be placed on an effective reduction of rat numbers, preferably by the use of poisons in appropriate areas by trained personnel. Greater care must be exercised in the handling and disposal of food wastes to prevent the stock-piling of available supplies upon which rats thrive and multiply. Their access to storage facilities must be prevented to preclude damage and contamination of human foodstuffs. Refuse must be collected frequently and either burned or buried to eliminate rat harborage.

Control of rats in the "field" is a much more difficult undertaking in consideration of their widespread distribution and migration into less readily accessible areas. Rats in these natural habitats on the island provide a populaton reservoir from which a reinvasion of improved areas is merely a matter of time. Under the present conditions, the use of the man power required to accomplish a significant reduction of this reservoir population seems justified. Those concerned with the destruction of bird life by the fox on Adak might well consider the role of the brown rat in this connection. If Adak is to remain a valuable bird refuge, at least a severe reduction of feral rats seems imperative. In the opinion of the writer, the excessive economic losses, the potential menace to public health, and the threat to the bird fauna of this island are sufficient reasons to justify combining the program of rat extermination with that proposed for the foxes. In order to achieve more than a temporary measure of control in the improved areas, it would seem only reasonable to institute effective control practices in the outlying districts at the same time; otherwise, even a marked reduction in one may soon be replaced from an excess of rats in the other.

Acknowledgments.—The writer wishes to take this opportunity to express appreciation to Colonel David, Commanding Officer, Davis Air Base, Adak, for making available certain facilities which aided considerably in the accomplishment of this study. Thanks are due also to Mr. Maurice Kelly, in charge of predator control, U. S. Fish and Wildlife Service, Anchorage, Alaska, for providing the rats obtained during his rat-bait experiments at the time this study was made and for authorization to take the foxes and bald eagles concerned in this work; to Dr. David H. Johnson, Associate Curator, Division of Mammals, U. S. National Museum, for confirming the rat identifications; to Dr. Jack Tiner, University of Illinois, for the identification of the fox nematodes, and to Dr. H. J. Van Cleave, also of the University of Illinois, for the determination of the acanthocephala from the bald eagles. The writer is especially indebted to Mr. Bert Babero, Arctic Health Research Center, for conducting the trichinosis digestions and making the larval counts. Appreciation is also expressed to Dr. Robert Rausch, Chief, Animal-borne Disease Branch, Arctic Health Research Center, for valuable criticisms and helpful suggestions in the preparation of this manuscript.

Summary.—Some observational notes on the ecology and helminth parasites of the brown rat on Adak have been presented. Reference has been made to the relationship of rats to other introduced land mammals on the island.

Five species of helminth parasites were recovered from 122 (54 per cent) of the 224 rats examined. Detailed information on these helminth infections has been included.

Since rats have become well established in the natural as well as in the improved areas on the island, a difficult extermination problem has been created. It is suggested that an attempt to control rats in the improved areas without control in the outlying districts at the same time would be ineffective.

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FOOD OF DEER MICE, *PEROMYSCUS MANICULATUS* AND *P. BOYLEI*, IN THE NORTHERN SIERRA NEVADA, CALIFORNIA

By E. W. Jameson, Jr.

Because deer mice (*Peromyscus* spp.) are abundant small mammals in most of the wooded and once-wooded areas in our western mountains, information concerning their food is necessary for an understanding of their economics in the forest. Much of the burned and logged forest land has been revegetated with brushy plants instead of the original coniferous growth. Most efforts to establish trees on these areas have failed, presumably because deer mice and small squirrels gather the planted seeds. Despite their abundance and the numerous technical reports concerning their habits, there has been little study of the food habits of wild individuals; and their role in reforestation is largely inferential.

Deer mice are generally nocturnal, unless disturbed, and one cannot make visual observations on them in the wild. There are several ways to study their food; fecal analysis, stomach analysis, and examination of midden heaps and food stores appear to be the least impeachable methods. In this study few piles of food remains were found, and for the most part they could not be ascribed definitely to any one species of small mammal. The food stores of mice may tell much about their diet in winter, but only if the species of small mammal is known; as many mice, voles, and insectivores store food and use communal tunnels, one cannot always be certain of the author of caches. Examination of feces is useful in studying diets of some mammals, but deer mice eat many different types of food which are not proportionally represented in scats. Remains of food in stomachs represent most accurately the meals of wild individuals; and the worker then has the advantage of knowing the day the food was taken.

By noting the plants present for the mice to eat, one can gain an initial impression of the possible food items at any particular place and time. The more common food items are fed to captive mice and the latter dissected; in this way it is possible to become familiar with the appearance of different plant parts after they have been eaten. The identification of seed fragments frequently is impossible, but in many instances the membraneous or leathery integument of a seed reveals the species eaten. Often these integuments are not ingested; thus, counting the individual integuments does not determine the number of seeds eaten. With large seeds such as those of sugar pine and acorns these coverings are not eaten. Insect remains, in the absence of sclerotized pieces, sometimes look superficially like the starchy paste of seeds, but the presence of tracheae indicates the true nature of this material. Leaf remains are identified by their color, vascular structure, and characteristic margins and hairs; cotyledons of sprouting seeds retain their green color in mouse stomachs, but this material becomes rather pasty, lacking the vascular structure of seeds.

It is desirable to make stomach examinations soon after the mice have been captured because food items in preserved stomachs lose much of their original

character. When removed from the mouse, the stomach is cut lengthwise and placed in a watch glass with a little water. The different kinds of food are usually stratified; a small amount of starchy paste is often found near the stomach entrance, and this is most likely bait. The volume of each kind of food was estimated to the nearest ten per cent, and in summaries the means are expressed to the nearest per cent. This approximation may seem crude to some workers, but any attempt at greater accuracy is unwarranted with these animals. The apparent exactness in many wild animal dietaries suggests a state of affairs which probably does not exist in nature; most wild species do not seem to select their food with delicate precision.

ENVIRONMENTS OF DEER MICE

Peromyscus maniculatus (Wagner) and *P. boylei* (Baird) were studied in Plumas County, California, on the western slope of the Sierra Nevada, at elevations of 3500 to 5000 feet, during 1949 and 1950. The annual precipitation is between 39 and 41 inches, virtually none

TABLE 1.—*Numbers of deer mouse stomachs examined*

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTALS
Peromyscus maniculatus													
1949	9	6	10	19	24	20	0	20	33	49	31	54	275
1950	31	35	47	47	29	39	48	39	72	35	47	34	503
Totals	40	41	57	66	53	59	48	59	105	84	78	88	778
Peromyscus boylei													
1949	25	32	16	12	18	19	0	25	26	14	27	15	229
1950	25	19	20	19	14	24	42	18	19	29	16	6	251
Totals	50	51	36	31	32	43	42	43	45	43	43	21	480

of which falls in the summer months. Although this is in the western drainage, the vegetation is somewhat more open than in other nearby localities where there is more rainfall. In the forest snow may remain on the ground from November or December until April or May, but in warm winters may last only a few days at a time. On brush-covered hillsides the snow melts rapidly, and affects mouse activity only for short periods. Deer mice were trapped in two vegetative types, brushfields and coniferous woodlands. Although both kinds of mice occur in each habitat, *maniculatus* is typically a woodland rodent, and *boylei* is common only in brushfields; *maniculatus* was trapped in brushfields much more frequently than *boylei* was taken in the forest. This environmental segregation, however, is not the case in other localities (Jameson, 1951).

In the coniferous forest the common trees are sugar pine (*Pinus lambertiana*), ponderosa pine (*P. ponderosa*), Douglas fir (*Pseudotsuga taxifolia*), white fir (*Abies concolor*), and incense cedar (*Libocedrus decurrens*). Broadleaved trees and shrubs are in the minority; commonest are black oak (*Quercus kelloggii*), huckleberry oak (*Q. vaccinifolia*), maple (*Acer macrophyllum*), ceanothus (*Ceanothus prostratus*, *C. integerrimus*, and *C. cordulatus*), and dogwoods (*Cornus californica* and *C. nuttallii*).

Many of the potentially timbered areas are now unforested, a result of severe logging and fires. The trees have been replaced by many kinds of shrubs, some of them broadleaved

evergreens that form dense and extensive brushfields. Most numerous of these are manzanitas (*Arctostaphylos patula* and *A. viscida*), various kinds of ceanothus (*Ceanothus cuneatus, C. integerrimus, C. cordulatus*, and *C. prostratus*), and silktassel (*Garrya fremontii*). Black oaks and conifers are present in small numbers.

TABLE 2.—*Food of Peromyscus maniculatus in the northern Sierra Nevada, California, 1949. Upper figures are volumetric percentages; lower figures (in parentheses) represent frequencies of occurrence*

FOOD	JAN.	FEB.	MAR.*	APR.*	MAY	JUNE	JULY	AUG.	SEPT.	OCT.*	NOV.	DEC.	MEANS
From Brushfields													
Seeds	80 (100)	27 (67)	60 (100)	0 (0)	—	6 (17)	—	30 (67)	55 (75)	0 (0)	30 (72)	59 (86)	35
Fruits	0 (0)	0 (0)	30 (100)	0 (0)	—	0 (0)	—	24 (67)	14 (25)	100 (100)	47 (78)	2 (5)	22
Arthropods	10 (100)	30 (60)	0 (0)	80 (100)	—	89 (100)	—	33 (100)	31 (75)	0 (0)	19 (39)	20 (86)	31
Leaves	10 (100)	1 (17)	10 (100)	20 (100)	—	2 (43)	—	13 (67)	0 (0)	0 (0)	3 (9)	15 (38)	7
Fungi	0 (0)	0 (0)	0 (0)	0 (0)	—	0 (0)	—	0 (0)	0 (0)	0 (0)	0 (0)	3 (5)	0
Misc.	0	42	0	0	—	3		0	0	0	1	1	5
From Coniferous Forests													
Seeds	60 (88)	—	50 (67)	68 (100)	36 (88)	18 (40)	—	22 (41)	64 (92)	62 (92)	68 (100)	76 (97)	53
Fruits	7 (13)	—	20 (45)	0 (0)	4 (17)	2 (7)	—	2 (6)	0 (0)	3 (4)	0 (0)	0 (0)	4
Anthropods	32 (88)	—	14 (55)	18 (61)	38 (92)	80 (100)	—	58 (94)	26 (52)	10 (42)	25 (88)	19 (67)	32
Leaves	1 (13)	—	16 (33)	7 (28)	18 (75)	0 (0)	—	11 (41)	8 (40)	10 (29)	0 (0)	3 (12)	7
Fungi	0 (0)	—	0 (0)	0 (0)	0 (0)	0 (0)	—	0 (0)	2 (4)	8 (10)	0 (0)	1 (3)	1
Misc.	0	—	0	7	4	0	—	7	0	7	7	1	3

* One specimen.

Although the diets of these two mice reflect their environments, they seem to have some characteristic differences in feeding habits. It is evident that their sustenance fluctuates with the cover, seasons, and years, and the results of the stomach analyses are arranged in these categories (Tables 2, 3, and 4). Mice were trapped at all seasons; 778 *maniculatus* and

480 *boylei* stomachs were examined (Table 1). To simplify the discussion and avoid repetition, the results for the two years are treated together; any differences, apparent to me, are pointed out in the text.

TABLE 3.—*Food of Peromyscus maniculatus in the northern Sierra Nevada, California, 1950. Upper figures are volumetric percentages; lower figures (in parentheses) represent frequencies of occurrence*

FOOD	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEANS
From Brushfields													
Seeds	48 (100)	67 (100)	38 (83)	42 (78)	28 (46)	33 (78)	12 (38)	45 (90)	34 (44)	47 (60)	19 (35)	0 (0)	34
Fruits	19 (42)	0 (0)	14 (48)	0 (0)	0 (0)	0 (0)	22 (25)	0 (0)	6 (19)	15 (17)	0 (0)	0 (0)	6
Arthropods	9 (69)	23 (75)	19 (64)	7 (45)	43 (85)	47 (100)	58 (91)	48 (80)	43 (81)	25 (67)	47 (91)	57 (80)	36
Leaves	18 (50)	2 (13)	20 (68)	32 (56)	13 (46)	3 (29)	7 (8)	6 (20)	10 (37)	2 (17)	19 (57)	10 (20)	12
Fungi	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	10 (15)	18 (20)	2
Misc.	6	8	9	19	16	17	1	1	7	11	5	15	10
From Coniferous Forests													
Seeds	81 (100)	81 (100)	73 (96)	80 (100)	59 (88)	35 (78)	27 (58)	49 (84)	62 (87)	29 (46)	26 (43)	14 (33)	51
Fruits	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0
Arthropods	16 (53)	11 (47)	18 (54)	16 (44)	21 (56)	27 (89)	58 (88)	31 (76)	25 (55)	25 (85)	30 (43)	29 (54)	26
Leaves	3 (16)	7 (44)	4 (24)	0 (0)	19 (63)	20 (55)	6 (17)	7 (35)	8 (32)	5 (35)	1* (14)	3* (24)	7
Fungi	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (6)	0 (0)	0 (0)	14 (23)	43 (72)	26 (33)	7
Misc.	0	1	5	4	1	18	2	13	5	27	0	28	9

* Not vascular material; probably algae.

PEROMYSCUS MANICULATUS

Winter.—Large crops of pine seeds, Douglas fir seeds, acorns, and berries of manzanitas and silktassel provide a winter supply of food for many kinds of mammals and birds. The Douglas firs drop most of their seeds in late summer, but freshly-fallen seeds of ponderosa

pine may be found from September until January. The seemingly paradoxical absence in stomachs of the very large seeds of sugar pine was probably because the mice did not ingest the integuments of these seeds; but doubtless many sugar pine seeds were eaten. Although much of the seed material of woodland mice was of conifer origin, that eaten by

TABLE 4.—*Food of Peromyscus boylei in the northern Sierra Nevada, California. Upper figures are volumetric percentages; lower figures (in parentheses) represent frequencies of occurrence. All specimens from brushfields*

FOOD	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEANS
						1949							
Seeds	10 (36)	20 (63)	25 (63)	21 (42)	17 (44)	16 (63)	—	13 (36)	34 (89)	35 (72)	31 (67)	33 (60)	23
Fruits	27 (40)	17 (31)	14 (50)	5 (17)	0 (0)	0 (0)	—	54 (72)	29 (58)	42 (79)	45 (67)	34 (73)	24
Arthropods	29 (60)	11 (38)	28 (69)	25 (58)	49 (89)	77 (100)	—	27 (44)	32 (77)	16 (58)	6 (48)	9 (53)	28
Leaves	20 (40)	41 (69)	27 (81)	33 (84)	19 (61)	2 (16)	—	2 (16)	0 (0)	1 (7)	6 (30)	15 (35)	15
Fungi	0 (0)	0 (0)	0 (0)	0 (0)	6 (6)	0 (0)	—	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1
Misc.	14	11	6	16	9	5	—	4	5	6	12	9	9
						1950							
Seeds	32 (68)	42 (74)	38 (70)	24 (79)	36 (64)	24 (46)	24 (53)	33 (61)	17 (37)	63* (79)	0 (0)	0 (0)	26
Fruits	30 (68)	3 (5)	15 (40)	24 (63)	0 (0)	0 (0)	8 (17)	39 (61)	21 (47)	0 (0)	1 (6)	0 (0)	12
Anthropods	11 (64)	18 (58)	18 (13)	4 (26)	37 (71)	70 (85)	44 (86)	26 (72)	47 (90)	23 (48)	15 (50)	5 (35)	27
Leaves	15 (52)	10 (35)	16 (55)	16 (47)	1 (7)	1 (8)	4 (10)	2 (5)	5 (5)	4 (14)	0 (0)	2 (17)	6
Fungi	4 (8)	5 (4)	0 (0)	0 (0)	0 (0)	1 (4)	6 (7)	0 (0)	0 (0)	7 (7)	84 (94)	92 (83)	17
Misc.	8	22	13	32	26	4	14	0	10	3	0	1	12

* Mostly acorns of the 1949 crop.

brush-dwelling *maniculatus* was not definitely identified, and probably came from acorns. In the feeding sites, generally recesses under projecting rocks or fallen trees, there were gnawed remains of acorns; these represented the work of either *maniculatus* or *boylei* and not woodrats (*Neotoma fuscipes*) which characteristically break acorn husks into pieces.

Less important than seeds in the winter food of *maniculatus* were the fruits of manzanitas and silktassel; these shrubs were eaten in quantity only by brushfield individuals; such shrubs are scarce in the forest.

In both habitats the mice ate a variety of arthropods, and the consistency with which these items occurred in stomachs suggests that the rodents are always willing to utilize this food supply. In winter months arthopods made about one-fifth of the total food of *maniculatus*. Spiders, caterpillars, and heteropterans were most frequently recognized. A large, rather distinctive cutworm was found in February and March; this noctuid larva was identified by Dr. H. H. Keifer as probably *Protorthodes rufula*.

When deep snow covered the ground in brushfields, *maniculatus* climbed *Ceanothus cuneatus* and silktassel to browse on the leaves, but the mice seemed to take this food only under duress, apparently foraging on the ground whenever possible. Most writers have emphasized the activity of deer mice on top of the snow, and some have used the number of tracks of mice to indicate numbers of these animals. In the present study it was interesting to find that large numbers inhabited a woodland where there was very little evidence of them on fresh snow. They were quite active under fallen logs, however, and were trapped in such places on nights when the temperature went below 0° F.

Some small birds were taken in the winter; they were probably juncos which are quite common in brushfields at that season. Occasionally there was mouse flesh in stomachs, but it does not appear that deer mice prey upon each other when there is an abundant supply of seeds and berries.

Spring.—With the first warm weather new kinds of food become available, and, possibly as a result, seeds were consumed in smaller amounts than previously. The seeds identified were ponderosa pine and Douglas fir, and a kind not eaten in the winter, maple samaras which were lying on the snow and beginning to sprout; these had dropped after the heavy snowfalls. Forest mice continued to eat maple seeds in May and June. Fruits were found in stomachs only rarely in the spring.

Most of the insects were so finely chewed that their original characters were obscured; but it was obvious that *maniculatus* consumed them in large quantities. The large cutworm which the mice ate in the winter assumed paramount importance; in June, 1949, it comprised 49 per cent of all food eaten by *maniculatus*, but in 1950 this insect was much less important in their diet.

Leaves eaten in the spring were from fresh and tender forbs, and were found rather consistently in mouse stomachs for a brief period.

Summer.—Mice ate the seeds of both forbs and grasses, and, in August and September, also those of ponderosa pine and Douglas fir. In 1950 the forest produced no mast, and this affected the rodents as early as August, when the mice could find only a few seeds from the previous year.

There were virtually no berries on either species of manzanita or on silktassel in 1950, although brushfield *maniculatus* ate these fruits in large amounts in 1949. In July a few fruits of *Ceanothus integerrimus* were eaten; although plants of this genus bore abundant fruit in 1950, they dropped to the ground early in the summer, and were seldom recognized in the stomachs.

In 1949 the mice feasted on the large cutworm, *Protorthodes rufula*, but this source was apparently less abundant in 1950 when it was less frequent in stomachs. The characteristic hemelytra of heteropterans were noted in a few stomachs and closely resembled those of stinkbugs (Pentatomidae).

Autumn.—In the autumn the mice gradually returned to their winter diet, but in the two years of this study the trend was drastically different; in 1950 there was a complete lack of conifer seeds, acorns, and berries of manzanitas and silktassel, attributed by some to a late frost which may have killed the flowers of these plants. In 1949 conifer seeds formed two-thirds to three-fourths of the food of the forest *maniculatus*; seeds of ponderosa pine and Douglas fir were commonly identified, but probably sugar pine seeds were also gathered and eaten. Berries of dogwood (*Cornus nuttallii*) were found stripped of their pulpy covering and with one end of the stone gnawed. In the stomachs of brushfield *maniculatus*, seeds

were somewhat less abundant, and none was recognized to be from conifers; probably acorns formed the seed material in that environment. In 1950 the drop in seed consumption was less than might be expected in view of the crop failure; the rodents compensated for this by eating such seeds as they could find of the 1949 crop. These included a few seeds of conifers and maples. For the first time manzanita seeds were taken; in 1949 the mice ate only the soft, pulpy part of the berries, and the uneaten seeds were left in heaps at the feeding places of deer mice. In 1950 they returned to these stones, and gnawed through to the small amount of food contained inside.

Berries of manzanitas and silktassel formed the mainstay of brushfield *maniculatus* in 1949, but this food was lacking in the forest. Of nineteen individuals examined from brushfields in November, 1949, fifteen had stomachs containing between 50 and 100 per cent manzanita berries (*A. patula*). In the autumn of 1950, however, this food was virtually absent in mouse stomachs.

Because of the abundance and diversity of arthropods, they formed the one constant staple for deer mice. Most of them could not be identified, but the large cutworm was found in mouse stomachs as late as October. Centipedes were eaten in October, November, and December. Two brushfield *maniculatus* had stomachs filled with small muscoid maggots, probably from a decaying deer carcass near the trapline.

In December, when snow again covered the ground for short periods, mice browsed on leaves of *Ceanothus cuneatus* and silktassel. The appearance of leaves in the diet of *maniculatus* in December, 1949, was coincident with the first deep snow. The importance of such snow is further emphasized by the virtual absence of berries (2 per cent) in December in contrast to the large amount (47 per cent) eaten in November. The supply of berries, however, was not exhausted, because the mice ate them again when the snow melted.

Fungi were eaten sparingly in 1949, but in 1950 this food, together with arthropods, replaced in a large measure conifer seeds in the diets of mice. The kinds of fungi taken were not identified, but many different species were eaten, mostly surface forms which became abundant after the autumn rains.

In November, 1949, one *maniculatus* from a brushfield ate a fence lizard (*Sceloporus graciosus*) which may have entered a mouse burrow for its winter rest.

Summary.—From this series of changes in the food of *Peromyscus maniculatus* a few generalities are apparent: there are regular seasonal shifts in the sorts of food eaten, different cover types provide major variations in the quality of food, and crop failures introduce inconstancies in the annual diet. Seeds are consumed in greatest quantity during the fall and winter, and in the spring in forested areas; there is a conspicuous decline in consumption of seeds in the summer. In the spring, sprouting seeds may assume importance in deer mouse diets. Berries may form a large part of the sustenance of brushfield rodents. Insects are the most widely distributed staple taken by deer mice, and may at times occur to the exclusion of almost every other item. The use of leaves is of two sorts, both seasonal: in the warm, wet periods of spring and fall *maniculatus* eats tender forbs, and, in times of deep snow, they may climb broad-leaved evergreen shrubs to browse. Fungi, when abundant, may form a large part of the food, but do not appear to be a favored food for *maniculatus*, and may be eaten only in the absence of other food. Miscellaneous kinds of food are numerous, but form only a small part of the food of these rodents; probably some of the vertebrate food, such as small birds and lizards, represents food killed by the mice.

PEROMYSCUS BOYLEI

Because almost all specimens of this species came from brushfields, an account of its food is relatively simple. In this environment there is a minimum of ground litter, and the lack of shade allows rapid heating and drying of places in which mice forage. These rather severe conditions appear to limit the kinds of food available to the mice to a small number. Although the same general classifications can be used for the food of both species of deer mice, *boylei* seems to concentrate its foraging on a few rather specific kinds of food, and this is more conspicuous when the food is analysed by seasons.

Winter.—Aside from a few seeds of forbs and grasses, most of the seed material came from acorns. A few conifer seeds were taken, but such food was common only where brushfields adjoined forested areas.

The berries of manzanita (*A. patula*) are on the ground in the winter. Snow doubtless hinders the mice in searching for them, but as it melts rather quickly in brushfields, the mice are not long kept from this sort of food. Berries of silktassel remain on the bushes in the winter. In 1949 both these fruits were found in stomachs repeatedly from January until March, but in the spring of that year the flowers of silktassel did not develop into fruits.

Arthropods formed a major food at all seasons, and were found in many winter stomachs of *boylei;* caterpillars, heteropterans, and spiders were recognized. The marked drop in consumption of arthropods during February, 1949, was probably caused by the deep snow which then prevailed.

At the time of deep snow *boylei* began to browse on leaves of silktassel and *Ceanothus cuneatus:* traps placed on main stems of these plants from one to five feet from the ground readily captured *boylei*, and one, so taken, had a twig and leaves of silktassel in its mouth.

In January and February, 1950, several individuals had eaten fungi. Mammals and birds occurred in several stomachs, and in March one *boylei* had eaten a fence lizard. Catkins from a manzanita were in one February stomach.

Spring.—In the spring of 1949 the mice ate a smaller quantity of seeds, and berries disappeared entirely from the diet. Most of the seeds eaten in 1950 were sprouting and appeared in mouse stomachs as a green paste, quite different from the chewed leaves which are easily recognized as such.

Compensating for the low consumption of plant food was the high proportion of insects, especially in May. In April and May the large cutworm, taken in quantity by *maniculatus*, became increasingly conspicuous in the diet of *boylei*. Geometrids, coccids, and isopterans were also identified. The leaves taken at this season came from herbs that remained green only a few weeks. Manzanita flowers were in the food of one mouse in May.

Summer.—Seeds were unimportant in the summer; but berries from manzanita (*A. patula*), when available, became the most important staple. In 1949 this was the only fruit eaten in August; at this time it comprised more than half (54 per cent) of the food of *boylei*. These shrubs bore no fruit in 1950, and any manzanita berries eaten then must have been left over from 1949. In July, 1950, a few soft green coverings of the capsules of *Ceanothus integerrimus* were eaten.

In June, 1949, the cutworm, *Protorthodes rufula*, made up 44 per cent of all food then taken by *boylei;* it was less important in 1950. Other caterpillars and pentatomid bugs were also eaten.

Autumn.—In 1949 seeds of Douglas fir and ponderosa pine were in *boylei* stomachs. Oaks produced many acorns in that year, and the gnawed husks occurred frequently at the feeding sites of deer mice. In 1950 there was no supply of acorns, cones, or berries of any sort. Seeds were unimportant in the autumn of 1950; in one area, in October, *boylei* reworked the acorns of 1949, but the gleanings appeared to be meager. At the same time these mice ate the seeds of manzanita in the manner as noted for *maniculatus*.

In 1949 the mice ate more manzanita berries than any other item; berries of *A. viscida*, although abundant, are smaller and perhaps less palatable than those from *A. patula*. Berries from *patula* made up almost half the food of *boylei* in 1949, but were not available in 1950. Insects formed a smaller part of the fare in the fall months.

In the autumn of 1950 immense quantities of fungi replaced fruits in the food of *boylei*. In November and December a variety of surface kinds were eaten, occurring to the exclusion of almost all other kinds of food; fungi formed 84 and 92 per cent of the food for these two months, respectively. The kinds found earlier in the fall may have been underground species (Tuberales); later the mushroom-type fungi were abundant, and partly eaten pieces were on the ground where the mice were trapped.

Summary.—Seasonal dietary changes are obvious in this study, and the two years showed differences imposed by varying supplies of food. Of approximately equal importance in the

diet of *boylei* are seeds, fruits, and arthropods, but at times of deep snow this rodent may browse heavily on broad-leaved evergreen shrubs. When abundant, and perhaps then only in the absence of a supply of berries, fungi may make up almost all the food of this deer mouse.

COMPARISON OF THE DIETS OF DEER MICE

The material of this study reveals differences between the food of *maniculatus* and *boylei*. As *maniculatus* occurred in two vegetative types, it is possible to distinguish differences due to availability from inherent specific preferences. If availability were unimportant in diet, the food of *maniculatus* would have been the same in both habitats; and if availability were the sole determining factor, there would have been no differences in the diets of *boylei* and brushfield *maniculatus*. Apparently both elements determine the food of these deer mice, for the diet of *maniculatus* in brushfields in 1949 was intermediate between that of forest-dwelling individuals and *boylei* (Fig. 1). This situation is best illustrated by the

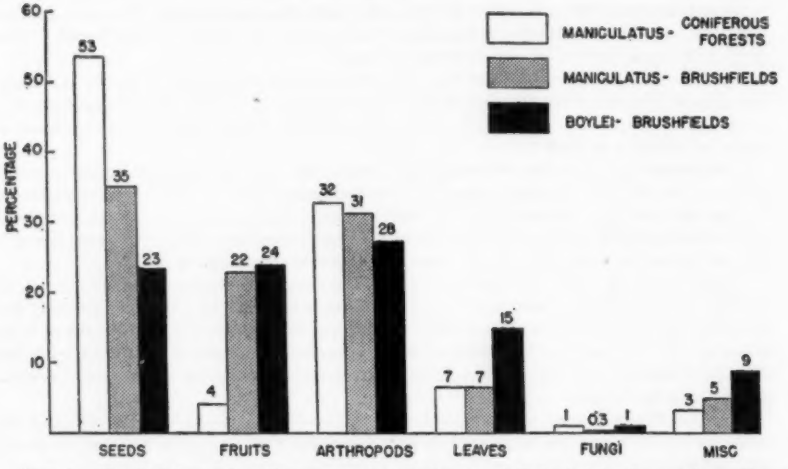

FIG. 1.—Food of deer mice, *Peromyscus maniculatus* and *P. boylei*, in the northern Sierra Nevada, California, 1949.

consumption of seeds, fruits, and arthropods, the three most important types of food. This gradation was partly broken in 1950 (Fig. 2), the discrepancy having been caused by the apparently greater fondness of *boylei* for fungi and *maniculatus* for arthropods.

The food of these two Sierra Nevadan deer mice resembles, in a general way, that of *P. maniculatus* and *P. leucopus* in New York State, as studied by Hamilton (1941). He studied the stomach contents of wild-caught individuals from mixed coniferous and deciduous woodlands. Hamilton observed no marked seasonal differences in the food of the two deer mice in New York, and in this they differ from the two species studied in California. One can account for such disparity, however, by the source of food and the unlike weather cycles. In a central New York woodland there are many more species of trees and shrubs which provide rodents with nuts, berries, buds, and leaves; and the period of availability is much longer than in California where deer mice obtain their food from a relatively few species of plants. In New York the seasonal changes in weather are less severe, at least with respect to rainfall; and summer rains stimulate the growth of such items as fungi which, in the Sierra Nevada, are abundant only in autumn. In general the deer mice from the two parts of the

country eat much the same sorts of food. Hamilton emphasized the dietary importance of insects; they occurred in almost three-quarters of all stomachs he examined.

The Eurasian mouse *Apodemus* is considered to resemble *Peromyscus* in its habits, and it is interesting to see how alike they are in their feeding. Sviridenko (1940), assisted by ten compatriots, studied the food of *Apodemus sylvaticus* and *A. flavicollis* in a broad-leaved forest near Moscow. The diets of these two mice are similar, and are much like those of the deer mice studied. Sviridenko observed that both kinds of *Apodemus* were much given to eating green vegetation in the spring, but in August and September many fruits were taken; in October they fed on hazel nuts, acorns, and lime fruits. By experimental feeding he determined that both species rejected maple fruits until ripe. This might explain why deer mice did not eat them until spring, at which time they had turned green

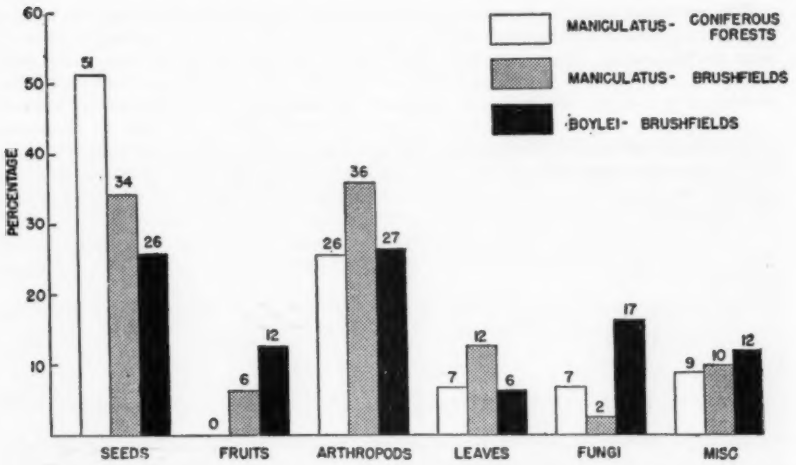

FIG. 2.—Food of deer mice, *Peromyscus maniculatus* and *P. boylei*, in the northern Sierra Nevada, California, 1950.

CONTROL OF DEER MICE ON SEEDED AREAS

The information on food of deer mice presented above may be useful in planning a program of seeding burns and brushfields. There is little question that deer mice, along with other mice, chipmunks, trees squirrels, some ground squirrels, and certain birds, may dig up conifer seeds just as methodically as foresters put them in the ground. The cause and extent of this damage probably varies in different regions and years, and this ought to be kept in mind when planning protection for seed spots. This subject has been reviewed by Smith and Aldous (1947) who discussed the protective measures that have been used, and cite many pertinent papers.

Despite the potential destructiveness of deer mice, these rodents are a powerful beneficent force as consumers of insects. It is not feasible to compute the numbers and kinds of insects these rodents destroy, but it is sufficient that they eat large numbers of insects, and that they are so fond of the large noctuid caterpillars which may be important enemies of newly-germinated conifer seedlings. According to Fowells (1940: 591), on an experimental planting area in the Sierra Nevada, cutworms killed more conifer seedlings than any other agency, accounting for 44 per cent of the losses. The species concerned was *Euxoa excellans infelix* (Sm.), but he stated that probably other species also injure seedlings.

In reforesting land by seeding there is need to be aware of the dual role of deer mice: without ignoring the trouble they cause to seed spots, one should remember that they do great good by destroying appreciable numbers of cutworms, and probably other harmful insects. The insect-eating habit of deer mice is still little appreciated, but in this respect they may be far more useful than insectivorous birds: deer mice are generally far more numerous than small birds, and they remain in the coniferous forests throughout the year. Shadle (1942) wrote of the foraging and eating of adult moths and caterpillars by *Peromyscus leucopus;* captive mice would take twenty-five or more noctuid moths. One enthusiastic champion of these little rodents recommended the systematic destruction of screech owls, because they fed on deer mice! Although this attitude seems a bit violent, the basic philosophy—to encourage the consumption of insects by deer mice—is certainly a sound one, and is to be commended.

The problem remains for the forester to learn means for preventing rodents from robbing seed spots without hindering their destruction of insects. The latter is impossible when the mice are eliminated. There is another objection to the general use of poison and other destructional methods in protecting seed spots. Even with the most efficient means of rodent control, it is virtually impossible to eliminate all individuals of all seed-eating kinds of mammals; and it is most unlikely that the protection obtained approaches the percentage of the kill. In other words, destruction of 90 per cent of the resident rodents will not necessarily reduce their depredations by that amount; more probably the remaining rodents will gather the seeds anyhow, although it may take them a little longer. There appear to have been few instances of rodent control giving good protection to seed spots, and this is one of the more likely reasons. At the present time there seems to be no perfect poison or satisfactory repellent, but it seems far more desirable to emphasize research on the latter type of protection.

This study was a part of a co-operative investigation by the California Forest and Range Experiment Station and the University of California at Davis.

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Division of Zoology, University of California, Davis, California. *Received March 26, 1951.*

A LIVE TRAP FOR POCKET GOPHERS

By Walter E. Howard

Traps to capture pocket gophers alive have been described and figured by Scheffer (Jour. Mamm., 15: 197–202, 1934), Sherman (Jour. Mamm., 22: 182–4, 1941), and Ingles (Murrelet, 30: 55–6, 1949). The trigger mechanism of all of these models must be set before the trap is placed in front of an exposed gopher tunnel and covered with soil; furthermore it is impossible, without removing any of them, to learn whether an animal has been captured. To overcome these objections and to facilitate the taking of gophers in numbers, a somewhat different design has been made. The principle advantage of the trap here described is that it may be put in place and covered with soil before being set. Also, on subsequent examinations a person can see whether the trap is still set without first digging it up (Pl. I).

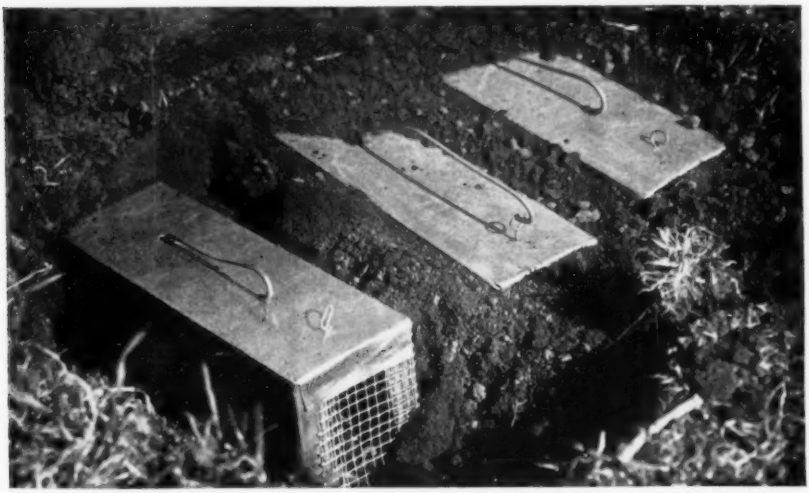


PLATE I

Live traps for pocket gophers. Left: trap in place at entrance to exposed burrow, but not set. Center: trap buried (soil should also cover top of trap) and set by engaging wire attached to door with loop of trigger. Right: trigger mechanisms disengaged indicating a captured gopher.

While developing the present trap it was noticed that pocket gophers would only occasionally enter traps having a sheet metal floor, but did so readily when the bottom was made of hardware cloth. The wire mesh permits soil to be forced up through the bottom if the trap is moved back and forth a few times when being set. Also, a gopher's long claws can extend through the mesh and

into soil which makes the trap floor resemble more nearly the natural environment of the burrow. The three previous designs referred to above also have hardware cloth bottoms, the Scheffer and Ingles models being cylinders of hardware cloth.

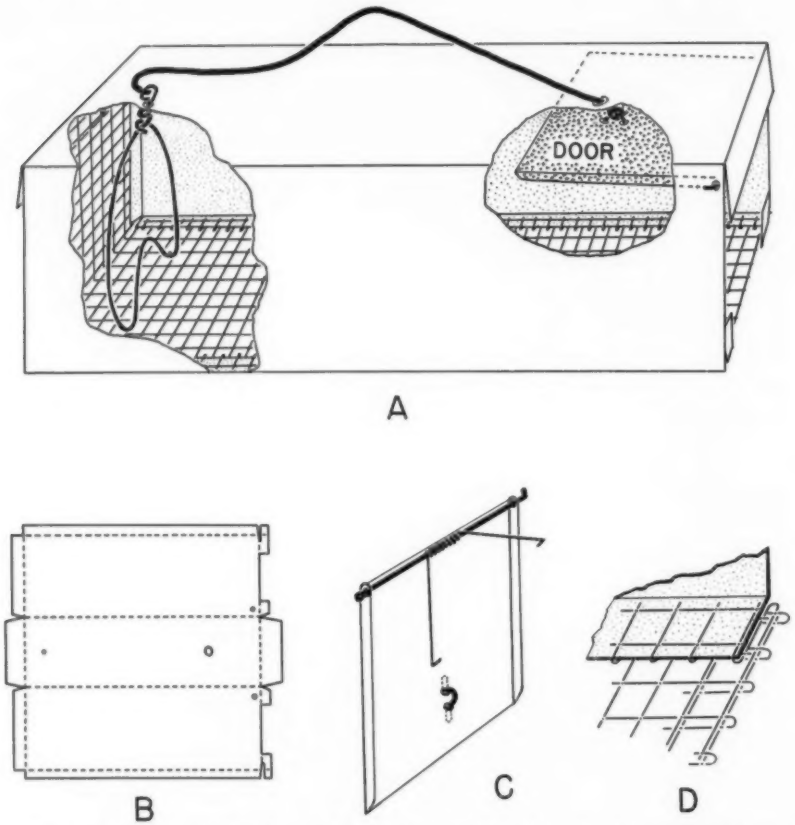
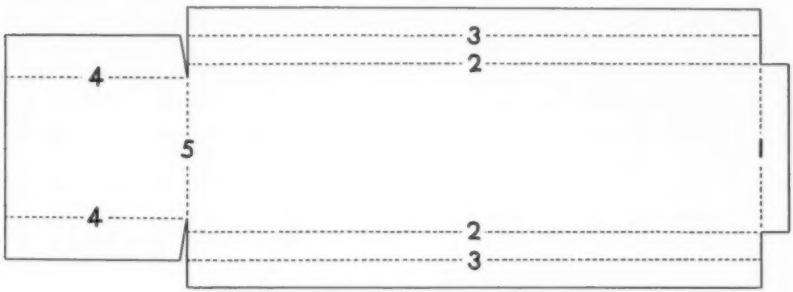


FIG. 1.—A live trap for pocket gophers: (a) perspective view of entire trap; (b) plan of trap body (11 x 12-inch sheet of aluminum) showing cuts, holes, and bends required; (c) galvanized iron door and piano wire spring; and (d) manner in which hardware cloth is folded twice so that it will slip over the bottom edges of the trap and the double thickness of wire mesh at forward edge of trap to prevent a captive gopher from unraveling the wires while trying to escape under door.

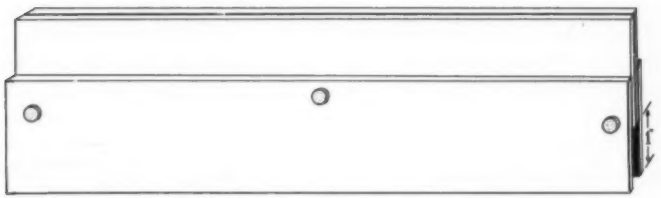
The body of each trap is 3 x $3\frac{1}{2}$ x $10\frac{1}{4}$ inches, being made from a sheet of 20-gauge aluminum measuring 11 by 12 inches (Fig. 1, B). This metal is inexpensive, light in weight, and easy to cut and form. The four longitudinal bends are obtained with a sheet-metal brake, although they can be formed around a

template of either wood or metal. Other bends at the ends of the trap (Fig. 1, A) are done with pliers and hammer.

The wire bottom and the rear end of the trap are made from one piece of $\frac{1}{4}$-inch-mesh hardware cloth measuring 5 x 14 inches (Fig. 2, A). At the forward edge of the trap floor a section of the hardware cloth measuring $\frac{1}{2}$ x 3 inches is bent (Fig. 2, A, Bend No. 1) back beneath (Fig. 1, D) to prevent captive gophers from unraveling the wires when they try to get out under the door. A strip one



A



B

FIG. 2.—A. Plan of trap floor and rear end made from one piece of $\frac{1}{4}$-inch-mesh hardware cloth measuring 5 x 14 inches, showing cuts and five bends required. B. Four pieces of sheet metal riveted together for making bend No. 2 on the hardware cloth bottom of trap (a si nilar tool with slot $\frac{1}{2}$-inch deep makes bend No. 3).

inch wide along each side of the floor is folded up and in (Fig. 2, A, Bend No. 2) with a bending tool. The latter is made from four pieces of sheet metal (each 2 x $10\frac{1}{4}$ inches) riveted so as to provide a slot one inch deep (Fig. 2, B). The wire mesh is inserted into the slot and bent over by use of the tool. Then, using a similar tool (but with a $\frac{1}{2}$-inch slot), a half inch strip is folded back outward (Fig. 1, D; and Fig. 2, A, Bend No. 3). This makes a slot along the sides of the trap floor so that the wire bottom can easily be slipped on and off the rear of the trap (Fig. 1, A and D) should repairs be necessary. The rear flap of hardware cloth is 4 inches wide and $3\frac{1}{4}$ inches long. A $\frac{3}{4}$-inch strip is folded (Fig. 2, A, Bend No. 4) up and in along each edge. After the wire floor is slid into place,

the rear flap is bent (Fig. 2, A, Bend No. 5) up 90 degrees and held in place under a piece of aluminum bent down from the top of the trap (Plate I). Bends 1, 2, and 4 should be crimped by tapping with a hammer.

The door is of galvanized sheet iron (Fig. 1, C). If aluminum is used gophers will occasionally gnaw through in trying to escape from the trap. They do not gnaw the body of the trap, which is aluminum, because no free edges are exposed. The door spring consists of eight turns of No. 20 piano wire (by W & M Standard Wire Gauge). The axis for the door and the trigger suspension are made from No. 16 galvanized wire. The release bar mechanism that projects through the top of the trap is of No. 11 galvanized wire. One end of it is hammered flat and a hole drilled through the flattened surface to facilitate hinging the wire to the door (Fig. 1, A).

To set a trap, an active runway is located by probing near fresh gopher mounds. (A convenient probe can be made from a 12-inch length of No. 8 galvanized wire with a ring turned on one end and the other end sharpened to a dull point.) The burrow is then exposed by using a short-handled shovel and a space is leveled in front of the tunnel for the trap. A small handful of rolled oats (wheat or barley) is thrown back into the burrow as "forebait." Another handful of bait is placed in the trap, which is then put in place and moved back and forth several times to force soil up through the wire mesh. Sometimes, before the trap is covered with dirt, a pinch of bait is also placed outside but adjacent to the rear of the trap. Most of the excavated soil should be packed firmly around the trap with the hands. The entire body of the trap should be covered with soil to provide insulation, just enough being brushed off the top to permit setting the trigger. To set the trap, the release wire (which extends along the top and attaches to the door) is pulled back and hooked into the trigger loop projecting through the top of the trap (Plate I, center). A gopher releases the door by moving the trigger wire hanging in the rear portion of the trap while gathering bait or pushing soil about in the trap.

A pocket gopher usually plugs any opening made into its burrow system, and because of this behavior an animal may be attracted into a live trap if a small opening is left at the rear of the trap. In general, however, the traps here described have proved more successful when completely covered. Regardless of how a trap is set, a surplus of bait should be placed in it to keep the captive animal in better physical condition. During cold weather it is imperative to provide sufficient bait to prevent trapped gophers from dying of "cold weather starvation"—starvation without much loss in weight as a result of insufficient food to maintain body temperature (Howard, Jour. Mamm., 32: 300–312, 1951). Unless a trap is covered with soil, or otherwise shaded, a captive gopher will quickly die during hot, sunny weather.

Traps may be left set during the day as well as at night since gophers are active at all times. The traps can be profitably examined in the morning, about noon, late in the afternoon, and, if convenient, during the night. Individuals are sometimes caught within an hour after a trap is set. To determine whether more than one gopher is living in the same runway, two or more traps can be

set side by side. Traps are often plugged by the gophers when the soil is sticky following a rain. Apparently the animals usually push a little dirt in front of them while entering the traps and the mud prevents the door from closing. On other occasions they completely plug the traps with soil, then later dig a tunnel through this plug to get at the bait. Some success has been had in preventing the plugging of reset traps by the operator plugging the burrow-opening with a mixture of bait and dirt before the trap is put in place. Then, when the gopher digs for food in the plugged tunnel, he opens passage into the trap without first pushing dirt into it.

About 80 of these traps have been used successfully during the past three years for trapping *Thomomys bottae mewa* (adults weigh 50 to 100 grams) on range land at the San Joaquin Experimental Range, O'Neals, California, and, to a lesser extent, for *T. b. navus* (100 to 200 grams) in irrigated alfalfa fields at Davis. To locate an active burrow and set one trap, it requires five to fifteen minutes, and unless one devotes full time to trapping, he can operate at one time only twenty-five to thirty traps. In irrigated alfalfa or other areas where the vegetation is green in the summer, gophers are active near the ground surface throughout the year. During the dry, hot summer at the San Joaquin Experimental Range, however, there is so little gopher activity in evidence that burrows are dug open and left that way for a day. Traps are then set only at those systems which gophers have plugged. The efficiency of the traps has not been measured in detail, for at the Range a surplus of traps is set in order to catch the entire population in the trapped area. In general, however, from 25 to 75 per cent of the traps set capture one or more gophers during a 24-hour period. As a test, one trap was carefully set six times at widely separated burrow systems during a two-day period and six gophers were trapped. Gophers apparently do not become trap-wise, for some individuals have been recaptured many times for more than two years. Often, after a gopher is released, it is caught again in another trap inadvertently set in the same home range a few minutes or hours later.

Since pocket gophers alter their burrow systems, fixed trapping stations cannot be established as is commonly done in the study of other nonfossorial small rodents. To facilitate recording exact trap locations, a field plot can be staked in a grid pattern of about 20-foot spacing. One coordinate on the stakes can be numbered and the other lettered. The trap location can be recorded in pencil or ink on the aluminum trap. After an animal has been released the writing on the trap can be removed by blowing one's breath on it and then wiping it off with a thumb. (Methods of marking and handling gophers and suggested problems of study are discussed by Howard and Ingles, Ecol., 32: 537–44, 1951.)

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FOOD HABITS, GROWTH, AND BEHAVIOR OF TWO CAPTIVE PINE MARTENS

By Jack D. Remington

About June 15, 1950, a little girl was attracted to a rock pile near Rabbit Ears Pass, north-central Colorado, by the barking of her dog. She investigated, dug out two small martens, *Martes caurina origenes* Rhoads, took them home and placed them in a cage. A wild marten, presumably the mother of the two captives, was seen near the cage on numerous occasions during the first few days, after which it disappeared and was not seen again. During the next two weeks the young animals were fed various things, and were found to be especially fond of candy and other sweet foods.

Tourists and others saw the young martens daily, and they were variously misidentified as "little foxes," "honey bears," etc. Colorado Game Warden C. A. Hurd of Steamboat Springs advised the family that they were martens, and since they were protected fur animals they could not be legally held in captivity. Mr. Hurd called Dr. Lee E. Yeager of the Colorado Cooperative Wildlife Research Unit and asked if the martens would be useful for study. On June 30, 1950, Dr. Yeager assigned them to the writer, who was working on a marten investigation in Colorado.

Description of capture site.—The writer examined the rock pile about six weeks after the martens had been removed. The location was within 50 yards of U. S. Highway 40 and about 75 yards from a well-used public camp ground. The general vegetative type of the area was Engelmann spruce–alpine fir with a mixture of lodgepole pine. The rock pile was in a moist, open draw next to a willow thicket, and covered a circular area only 10 or 15 feet in diameter. There were no holes that appeared deep enough or extensive enough to house a family of martens. It is not certain that a litter had been born and reared there; if so, the site had been abandoned by the mother and any remaining young ones. Among the rocks were hairs and bones of a snowshoe hare, *Lepus americanus*, and a few feathers from a woodpecker, probably the three-toed form, *Picoides tridactylus*.

Caging and handling techniques.—The martens (a male and female, Pl. I) were kept together in a cage outside the writer's headquarters cabin near Lake Agnes, Jackson County, Colorado. The elevation was 10,500 feet, and exposure and temperature factors approximated those in the surrounding spruce–fir forest. Later, the animals were moved to Trappers Lake, Garfield County, Colorado, and kept under comparable conditions.

The cage was about 4 by 4 feet, and 6 feet high. The roof and floor were of rough lumber and the sides enclosed with ordinary wire screening. The cardboard nest box, which enclosed some felt padding as bedding, had to be held down with a large rock; otherwise it would have been turned over and torn up by the active martens. The water pan was nailed down for the same reason.

The martens were handled with bare hands for the first three weeks. After that, well-padded mittens were necessary. They violently resisted handling,

and would scratch and bite constantly. A small, spring-type scale was used for weighing them; weights were taken in grams. The procedure was to catch one of the martens, push it into a sugar sack (later one of wire mesh), and hang the sack on the scale. It was possible to obtain a reading to the nearest 5 grams between jumps of the animal.

Food habits.—After the writer assumed custody of the martens they were fed as natural a diet as possible, but it was found that they would eat almost anything put into the cage. The only exceptions were a live toad and a live salamander. The female started to gnaw on the toad, but soon gave up, spitting and hacking as if the toad had a very bad taste. Neither marten would touch the salamander.

PLATE I

Young martens, about eleven weeks old. Note shape and contours of head and neck (left), and plantigrade front foot and dark tip of tail (right)

During the month of July, 1950, they were fed twice a day and after that usually once a day. On one occasion it was necessary to leave them for five days. Enough food and water for the entire period was put into the cage, but it is assumed that it was eaten during the first two or three days. When the writer returned, the martens were active and in good condition, but very hungry.

The pair fought over any food that was put into the cage, even though there was more than both could handle at one time. They nearly always carried food into the nest box; otherwise some cover would be sought under which to eat. A few times live animals were given to them and it was always the female that made the kill by biting the head and neck. Usually the mouse or other victim was dragged into the nest box even before it was dead. This behavior may be one reason why few evidences of marten kills are found while tracking them in the snow; wild martens may also prefer to eat under cover, even though the prey may have been caught in the open.

The first bite on small animals (alive or dead) was always at the head or neck. The martens consumed hair, bones, entrails, and feathers, as well as the flesh of mice, small birds, and other small animals. They left the feet and large bones of marmots and rabbits. These martens caught and ate flies and moths that got into the pen. They also ate grasshoppers, indicating that insects are one source of food in the wild. Droppings were left in the same spot in the pen; never in the nest box.

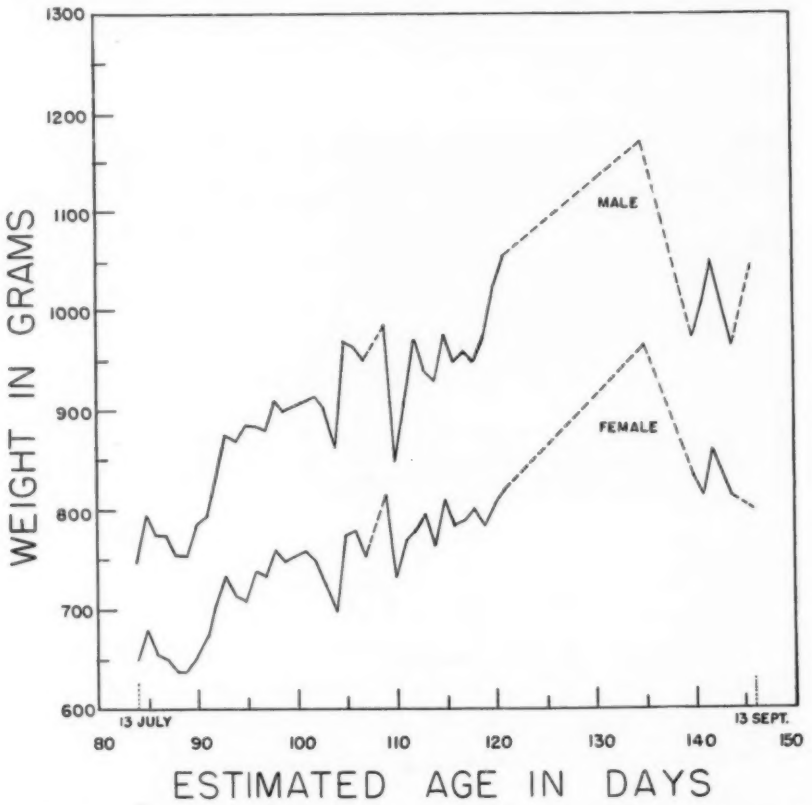

FIG. 1.—Growth rate of two captive martens. Dashed line indicates discontinuous record.

Food items preferred by the martens were: mice (alive or dead), ground squirrels, chipmunks, marmots, jack rabbit, small birds, cooked wheat cereal, gooseberries, raisins, and candy. Items less readily eaten were: shrews, venison (raw or cooked), beef (raw or cooked), ham (cooked), gravy (beef or ham), and pancakes (with or without syrup). Items eaten only when hungry were: trout (raw or cooked), grasshoppers, spaghetti, bread, celery, and lettuce.

Growth.—Between July 13 and August 19, 1950, the martens were weighed each day (except August 6) before the first meal. After that they were weighed seven times until September 13, 1950. A record of all weights is given in Figure 1.

Assuming April 15, 1950, as the birth date of the animals, they were about 12 weeks old when weighing began. The male, at the beginning, weighed 100 grams more than the female, and exceeded her weight by more than 200 grams when weighing ceased two months later. The weight figures were analyzed statistically by Mr. Jack R. Grieb of the Colorado Cooperative Wildlife Research Unit. He concluded that there was a strong direct correlation (correlation coefficient $r = .9631$) between the two weight gains, revealing that the martens grew at the same rate during the recorded period.

Sanderson (Jour. Mamm., 30: 412–415, 1949) recorded weights of seven males and one female in a litter of long-tailed weasels. He said the female never weighed as much as the lightest male, and that her rate of gain continued about the same as that of the males until the animals reached approximately eight weeks of age. After that time she attained her peak weight at a slower rate than did the males.

Behavior.—The young martens were active most of the night and especially at dusk and dawn. They moved around some during daylight hours, but seldom between 10:00 A. M. and 3:00 P. M. After feedings (during which they fought, sometimes viciously) they would roll and play like kittens. Their play was very rough, but they never seemed to hurt each other. They snarled and growled often, the growl resembling that of a raccoon.

When a person approached the pen, the martens would take a quick look, then dive for cover. When the writer cleaned the cage, they would retreat as far as possible, sit watchfully, and growl. They liked to climb up on anything available and jump off. One accomplishment was to hang from objects, using either the front or hind legs alone. They slept curled up together, presumably for warmth, under any available cover.

The female was more nervous and more curious than the male. She made all kills of live animals put into the cage, and resisted handling more violently. She was also the one to attempt escape and succeed. Luckily she stayed near the pen in the surrounding woods. To recapture her, the writer constructed a trip mechanism which would drop the trap door when the bait (a piece of meat) was pulled from inside the cage. Within an hour the marten was recaptured.

On September 12, 1950, the two martens were moved to Fort Collins, Colorado, which is at an elevation of 5000 feet and about 50 miles from the closest marten habitat. In spite of the change in environment they seemed at first to thrive.

On October 2, 1950, the male was found dead in the cage, apparently the victim of the female's viciousness. The head and two front legs were torn from the carcass, but only the heart and lungs were missing. The female was retained, and during the last week of October became so weak that she lost interest in

food and even allowed persons to pet her. On October 31, 1950, she died from what appeared to be a respiratory infection.

[A contribution from the Colorado Cooperative Wildlife Research Unit, Colorado A and M College, the Colorado Game and Fish Department, The Wildlife Management Institute, and the U. S. Fish and Wildlife Service, cooperating]

Fort Collins, Colorado. Received April 2, 1951.

THE OCCURRENCE AND SIGNIFICANCE OF EXTRA MOLAR TEETH IN RODENTS

By David H. Johnson

The presence of an additional tooth at the posterior end of the molariform series in rodents is comparatively rare, judging from the few such instances that have been recorded. If the customary theory, that the three cheek teeth of the normal tooth row in muroid rodents are true molars, is to be accepted, this additional tooth must be considered a fourth molar. It has been suggested on the basis of other evidence by several authors (Major, 1872; Hinton, 1910, p. 490; Kellogg, 1922, pp. 249–255; Hinton, 1923) that among rodents the anterior tooth in the series is homologous with the fourth deciduous premolar of other mammals (but not with the permanent premolar that usually replaces it), and that the remaining two teeth correspond to the first and second molars. If this is true, an occasional vestige of the lost third molar might be expected to appear at the posterior end of the tooth row. There is substantial evidence in favor of the latter theory, and it might have come into general acceptance long ago except for the awkward matter of altering the terminology of rodent teeth. The question has not been settled, however, and it seems worth while to put on record any new evidence that bears on the subject.

The specimen that stimulated the present comment is a subadult male of the large arboreal rat *Mesembriomys gouldi gouldi* (U. S. National Museum no. 284349). It was collected on September 10, 1948, at Gove, near Yirrkala, on the northeastern coast of Arnhem Land, Northern Territory of Australia. The dentition is fully irrupted and only slightly worn. The three usual cheek teeth of each upper and lower row are normal in size, position, and configuration. The additional tooth appears at the posterior end of the right maxillary row (Plate I, upper). There is no trace of a similar tooth in the left maxillary or in either mandibular series, nor is it present in any of five other skulls of the same species from Arnhem Land.

The tooth projects 1.4 mm. beyond the rim of the alveolus, thus reaching about to the level of the greatest expansion of the crown of the preceding molar. Its surface is unworn, and it appears that in life the tooth was still covered by the tissue of the gum. The greatest diameter of the crown is 1.8 mm., transverse to the axis of the tooth row. The anteroposterior diameter is 1.0 mm. In cross-section the crown is kidney-shaped with the concavity on the anterior side. A large external cusp makes up most of the bulk of the crown; it has a bulbous

appearance and its otherwise smooth surface is broken at the summit by a rough depression shaped like a shallow crater. Two small cusps, which together con-

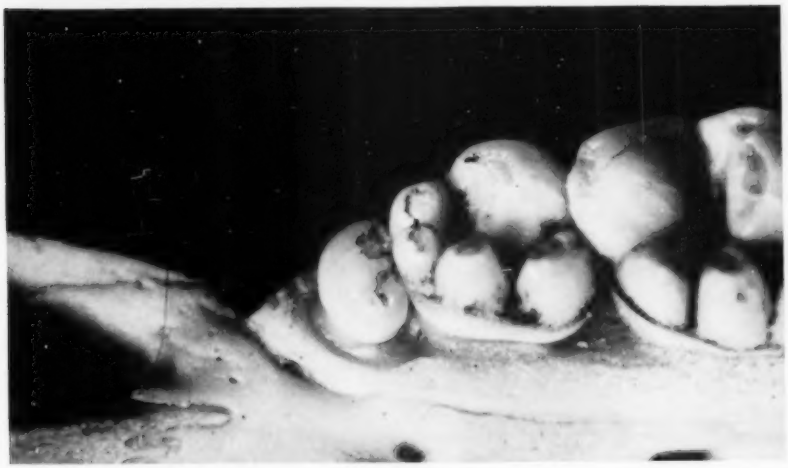

PLATE I

UPPER: Right maxillary toothrow of *Mesembriomys gouldi gouldi*, viewed from lingual side, showing extra posterior tooth, × 9¼.

LOWER: Same, occlusal view, showing pattern of cusps on the extra tooth, × 12⅔.

stitute less than a fourth of the crown, make up the internal or lingual part of the tooth (Plate I, lower). From the appearance and relative positions of these three cusps, it is believed that the large external cusp is homologous with the

middle cusp of the second lamina, and the small internal ones with the inner cusps of the first and second laminae, of the preceding molariform teeth. This arrangement would seem to be a logical continuation of the progressive reduction and disappearance of the cusps of the cheek teeth from front to rear.

The genus *Mesembriomys* belongs to the subfamily Murinae and is restricted to northern Australia. Other Recent rodents in which additional posterior cheek teeth have been recorded include an African murine, *Saccostomus hildae* (Schwann, 1906, p. 110); a European microtine, *Microtus agrestis* (Winge, 1881, pp. 24–25, footnote); an Asiatic porcupine of the family Hystricidae, *Hystrix leucura* (Major, 1904, p. 416); and two South American species of the family Echimyidae, *Proechimys longicaudatus* and *P. cayennensis* (Colyer, 1936, p. 150).

Except for the ones described by Colyer, who examined 2554 rodent skulls seeking such irregularities, these specimens were encountered incidentally in the course of other studies. A systematic examination of the many thousands of skulls in scientific museums would probably reveal further examples.

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U. S. National Museum, Washington 25, D. C. *Received March 28, 1951.*

A POSSIBLE ANTLER RUDIMENT ON THE NASAL BONES OF A WHITETAIL DEER (*ODOCOILEUS VIRGINIANUS BOREALIS*)

By George B. Wislocki

Multiple antlers springing independently from the frontal bones have frequently been described and depicted in a wide variety of deer. For example, Caton (1877) illustrates triplet antlers in a European red deer; Rörig (1901) describes a number of cases, besides showing three heads with 3 horns and one with 4 independent antlers in the European red deer, while Seton (1909) depicts triplet antlers in an elk, whitetail and mule deer. The accessory antlers described range all the way from nearly perfect reduplications of one or both of the antlers, located close to the normal antler pedicles, to very abnormal, much deformed or stunted antlers situated at more remote points on the frontal bones. Occasionally an abnormal third antler is situated midway between the normal antlers.

Fossil deer of the genus *Cranioceras* and subgenus *Procranioceras* possess an occipital horn in addition to the paired frontal pedicles and antlers, while *Sinclairomeryx sinclairi* possesses, in addition to the frontal antlers, small, paired excrescences or bosses on the surfaces of the anterior ends of the nasals (Frick, 1937). It is undetermined, however, whether these nasal horns in fossil deer were covered by deciduous velvet or permanent skin.

In recent Cervidae, growth of both normal and abnormal antlers appears to be confined to the frontal bones, as well as occasionally to neighboring parts of the parietals, except for three instances of abnormal bony growths observed upon the nasal bones. Dixon (1934) has described two of these and the third is reported here. In the case of two mule deer in the Yosemite Valley, Dixon noted a bony process, interpreted as an antler, growing out of the center of the face between the level of the eyes and the nostrils. In the first of these deer, this accessory antler first made its appearance as a single spike about midway between the eyes and the nostrils, but in the next year it developed two prongs with a height of $2\frac{1}{4}$ inches and a diameter of one inch at the base. This antler apparently shed its velvet to become hard and polished, and in the following spring it was replaced by a knob covered with velvet. In March of the final year, at the time of the animal's death, through an infection, this deer had shed his two main antlers, but the third one was still firmly attached. Upon examination of the skull, it was learned that the third antler was attached to "a socket in every way similar to the ones from which the 2 main antlers spring." A year later, in December, another buck was observed in the Yosemite Valley that had a similar, small, rudimentary third antler situated almost directly between the eyes. This antler, about $1\frac{1}{4}$ inches high, was at that date "out of the velvet and was hard and white like the polished tip of an ordinary antler." Although scientific proof could not be adduced, Dixon surmised that this buck was one of the progeny of the previous animal.

Observations.—A whitetail deer (*Odocoileus virginianus borealis*) described here also possesses what may possibly be an antler rudiment situated between the eyes. This deer was killed in November, 1950, in New Brunswick, Canada,

by Mr. James Campbell of Milton, Massachusetts, who donated its head for study. The buck was robust and in good health, possessing a well-developed set of antlers with eight points.

The structure in question consists of a circular, elevated plaque of bare bone an inch in diameter located in the midline of the head between the medial ends of the palpebral fissures (Pl. I). The surface of the plaque is brown and smooth,

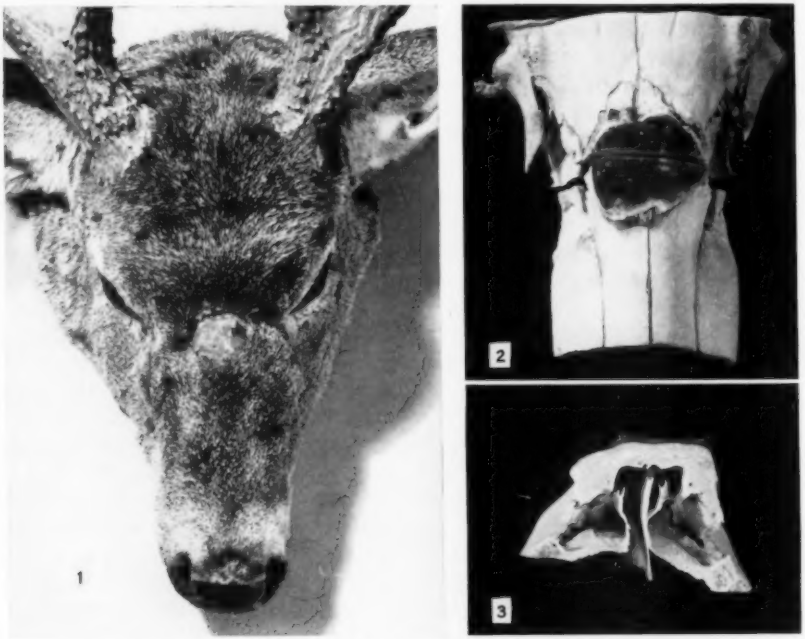

PLATE I

Fig. 1.— View of the head of the Whitetail deer, showing the bony plaque located between the eyes.

Fig. 2.—Part of the skull, with the flesh removed, showing the dark colored bony plaque situated in the mid-line on the nasal bones. The gap in the middle of the picture is where the specimen had been sawed in two to obtain a piece for histological study.

Fig. 3.—The bony plaque seen in transverse view, after sawing the nasal bones in two. The plaque consists of an elevated bony mass possessing a slightly undercut margin.

and possesses several low protuberances. After removing the flesh from the skull, the structure is observed to consist of an elevated plaque situated on the nasal bones just anterior to the orbits (Pl. I, Fig. 2). The plaque protrudes about a quarter of an inch above the surface of the nasal bones, and, after being sawed in two, it is apparent that it is three or four times as thick as normal nasal bones (Pl. I, Fig. 3). The circular brown area has distinct and slightly undercut margins bearing a slight resemblance to the corona of a normal antler. Other than

this bony plaque, there are no abnormalities of the skull. The nasal bones, except for the structure in question, are normal and symmetrical, and so, too, are the subjacent turbinates and nasal septum. The other skull bones, including the frontals and the paired antlers, are perfectly normal and symmetrical. After the plaque was sawed in two, a segment was removed, decalcified, imbedded in celloidin, and cut into histological sections which were stained. Examination of the sections revealed merely a plate of dense bone with normal skin on the margins.

Discussion.—The appearance, shape, and color of the plaque, as well as the relationship of the skin to its margin, suggest the possibility that it is an antler rudiment. The animal was killed in mid-November at a time when its regular antlers were devoid of velvet, highly polished, and brown in color—features which the bony plaque also shares. The similarity of the present structure to the larger ones described by Dixon on the nasal bones of two mule deer, one of which was very definitely shown to be a rudimentary antler, lends further support to the assumption that we are dealing in the present instance with an antler rudiment.

The skull of the present deer is entirely normal and there are no signs of old osteomyelitis in the neighborhood of the bony protuberance. Moreover, the surrounding skin and other soft tissues are healthy and present no traces of previous disease. Hence, there is no evidence that either disease or injury is immediately responsible for the formation of the structure in question. However, an initial injury, which may have left no trace other than the appearance of an antler-like rudiment, cannot be ruled out. Rörig (1901), for example, declares that all secondary or independent antler outgrowths originate from exostoses, which he attributes in turn to some previous injury to the frontal or parietal bones. He points out that such injuries may be inflicted by male deer upon one another during fighting in the rutting season or occur as the result of gunshot wounds.

In one of the two deer observed by Dixon, it was noted that the animal's regular antlers, although large, were misshapen and the pedicles assymmetrically situated on the frontal bones. This was not the case in the present deer.

Dixon suggested that the antler rudiment which he observed on the nasal bones might be hereditary, because the very unusual anomaly appeared twice in deer in the same locality. With this possibility in mind, it is interesting to recall that in the fossil genus *Sinclairomeryx* low bony protuberances are regularly present on the nasal bones while another genus of fossil deer (*Cranioceras*) bears a single, large occipital horn (Frick, 1937).

From what has been observed, all of the membrane bones of the top of the skull of Cervidae appear to be endowed with a potential for antler growth, although the capacity appears to be much stronger in the frontals than in the regions anterior or posterior to them. Thus, the frontal bones are favored, not only by normal antlers in most of the Cervidae, but also by a great variety of abnormal accessory antlers. In contrast to the frontals, antler growth from the nasal bones, both in the fossil genus *Sinclairomeryx* and in the three cases

observed in recent deer, is relatively slight, whereas horn growth in the occipital region is moderate in extent and appears to be restricted solely to the extinct genus *Cranioceras*. Antler growth does not appear to take place anywhere else than on the membrane bones of the skull for it has never been observed in any other parts of the skeleton.

Besides possible genetic and traumatic factors responsible for growth of antlers in abnormal sites on the skull, the possible role of hormonal factors should be borne in mind. The latter have been shown to play an important role in regulating normal antler growth and renewal, as well as in the experimental induction of antler growth in female deer (Wislocki, Aub, and Waldo, 1947; Aub, Wislocki, and Waldo, 1950). In so far as traumatic injury may serve as a stimulus and predisposing cause for growth of abnormally situated antler tissue, one would anticipate that it would be particularly effective during that period of the year when antler growth normally occurs. For the whitetail deer the time and manner of growth, as well as the nature of the hormonal factors controlling it, have been extensively investigated (Wislocki, Aub, and Waldo, *ibid*; Waldo and Wislocki 1951).

It should be mentioned that Rörig (1901) believed that injuries to the bones and soft tissues of the extremities of deer were often responsible for diminished and deformed growth of their antlers, and that the degree of antler deformation paralleled the severity of the injury. He believed also that injury to a front leg resulted in changes in both antlers, although greater in the one on the affected side, whereas injury to a hind leg invariably resulted, according to him, in deformation of the contralateral antler. The first part of this doctrine may have a basis of truth, in that extensive injuries involving the skeleton might conceivably interfere with the metabolic processes involved in bone deposition and hence affect antler growth. The second thesis, however, is patently unsound on physiological grounds and need not be considered.

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Department of Anatomy, Harvard Medical School, Boston, Mass. *Received March 2, 1951.*

FACIAL GLANDS OF THE TREE BATS, *LASIURUS* AND *DASYPTERUS*

By Henry James Werner and Walter W. Dalquest

In the current investigations on the facial glands of bats, the facial areas of the tree bats, *Lasiurus borealis* and *Dasypterus floridanus*, comparatively speaking, contain the largest amount and also the greatest variety of glandular tissue. Both species of these bats belong to the family Vespertilionidae, and are closely related genera. They are insectivorous in their food habits.

Four distinct groups of glands are recognizable: sudoriparous glands, sebaceous glands in association with and others independent of hair follicles, and two groups of different salivary glands. The types of facial glands are similar in the two species, differing only in relative amounts; in *Lasiurus borealis* fewer cells composing each gland are present—a miniature replica of the glands of *Dasypterus*.

Materials and methods.—Specimens of *Lasiurus borealis* and *Dasypterus floridanus* were collected in the immediate vicinity of Baton Rouge, Louisiana, during the summer of 1950. Entire bats and specific tissues were fixed in Bouin's solution. Dehydration and infiltration were carried out in ethyl alcohol and toluene. Tissue was embedded in parawax, cut serially at five microns, and subsequently stained in Harris' hematoxylin with an alcoholic eosin Y counterstain and Lillie's metachromatic dye technique.

Discussion.—Sebaceous glands are present in conjunction with both the small and large hair follicles. Glands of this variety have been found in all of the bats thus far investigated and have been described in an earlier report (Werner, Dalquest, and Roberts, Jour. Mamm., 31:395–99, 1950). This gland in *Lasiurus* and *Dasypterus* does not differ materially from the same kind of gland in *Tadarida* and other bats which have been studied. However, in both of the bats herein described, a modification of such sebaceous glands was noticed. Relatively huge nests of such holocrine glandular cells were found in both upper and lower labra. Each nest was a distinct entity, being surrounded by a connective tissue capsule and divided into lobes by penetrating septums of connective tissue. Of cardinal importance is the fact that the ducts of these glands open independently onto the surface of the skin in contradistinction to those which open into the shafts of the hair follicles.

Distributed throughout the upper and lower labra of both forms are numerous simple, coiled tubular glands. The wall of each secretory acinus of the gland has, between its basement membrane and the actual secreting cells, a series of flattened, tangentially disposed "myo-epithelial" cells (Pl. I, upper). Theoretically, such cells possess the property of contractility by virtue of which they facilitate the discharge of glandular secretion. The cells which compose the actual secretory portion are columnar and yet they frequently assume rather bizarre shapes reflecting, supposedly, the physiological state of the cell. The free surfaces of the cells often display bud-like protrusions of protoplasm. The term "apocrine" gland is sometimes used in conjunction with this type of sweat gland on the supposition that these terminal parts of the protoplasm become detached and

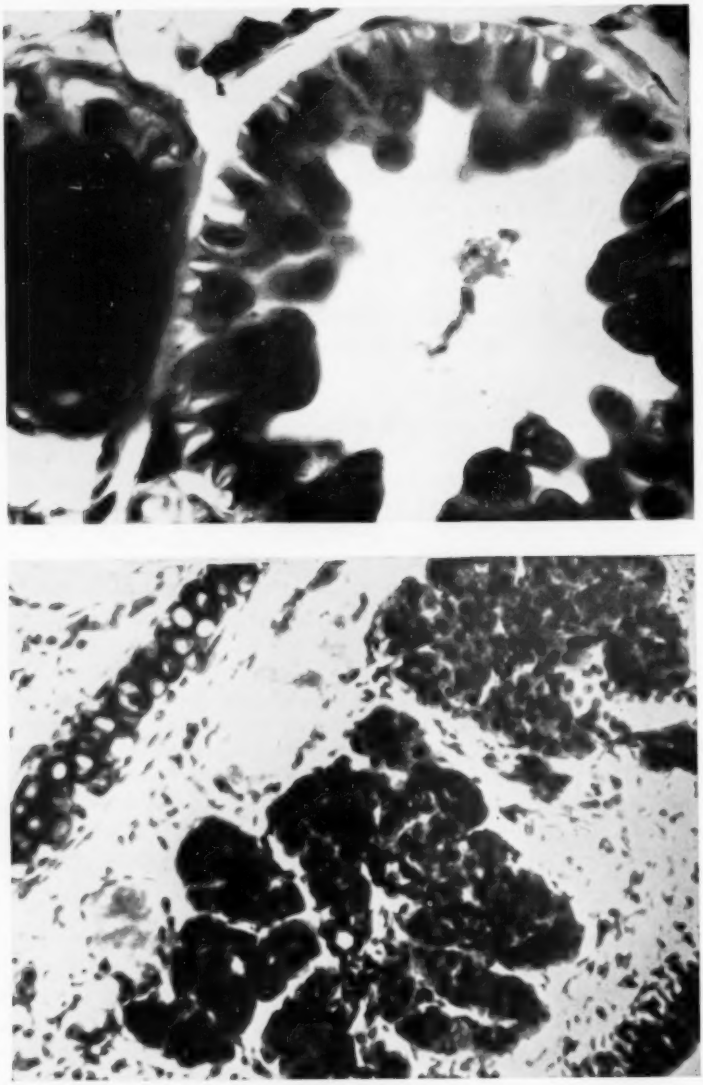

PLATE I

UPPER: Section through a secretory acinus of an apocrine gland. Myo-epithelial elements and protrusions of protoplasm both visible, about × 1000.

LOWER: Section of the submaxillary gland, about × 450.

eventually enter into the formation of the secretion. The majority of the nuclei are large, spherical, and show a fine chromatin network. The cells of the ducts become progressively smaller as they leave the gland until, at their termination, they are low cuboidal cells. Glands such as these were described by Harrison and Davies (Proc. Zool. Soc. London, 119: 351–57, 1949) in the European bat, *Noctula noctula;* however, they were not found by us in the labra of either *Tadarida cynocephala* or *Artibeus jamaicensis.*

Topographically and histologically two distinct types of salivary glands are present in *Lasiurus* and *Dasypterus.* The paired submaxillary glands are small, circumscribed nests of cells located anteriorly and just lateral to the nasal sep-

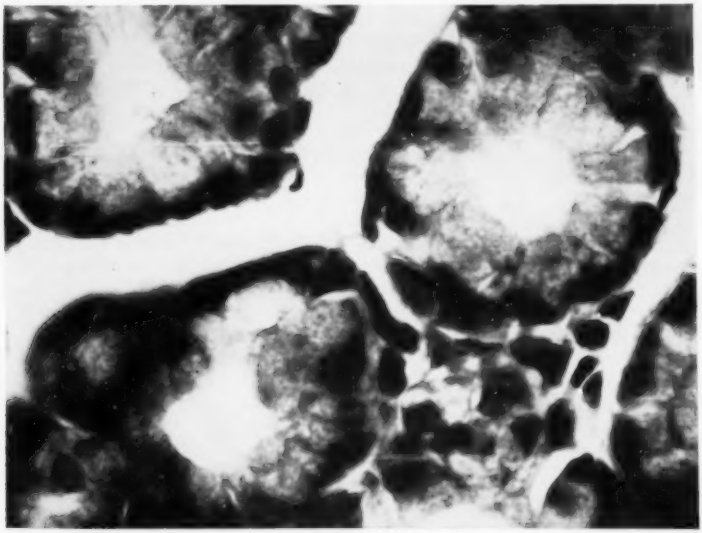

PLATE II

Section of the sublingual gland showing typical mucous cell configuration, about × 1000

tum (Pl. I, lower). The cells of these glands are roughly cuboidal in shape with indistinct cell boundaries. The centrally disposed nuclei serve as a guide in determining cell shape. The nuclei are small and highly chromatic. The cytoplasm is densely granular. Small, tubular lumina are present in the majority of the secretory acini. Histologically, the cells conform with the usual description of albuminous cells. However, the cells react positively and consistently, although in a much darker fashion, to the metachromatic stain. Because of this phenomenon one is justified in labeling them more specifically as being muco-albuminous cells.

The paired sublingual salivary glands are located deep in the dermis of the

lower jaw, near the corners of the mouth, internal to the longitudinally disposed striated muscle fibers, and embedded in a connective tissue capsule. The sublingual glands are composed of extremely large groups of true mucous secreting cells (Pl. II). The cells exhibit a positive reaction to the metachromatic stain technique. Mucous cells such as these are described in *Artibeus jamaicensis* elsewhere in this Journal (p. 102).

Summary.—The facial epithelium of the two insectivorous bats, *Lasiurus borealis* and *Dasypterus floridanus*, herein described show great diversity of facial glands. Sebaceous glands, both in association with and independent of hair follicles, are present in both labra. The latter were by far predominant. Apocrine sweat glands, with myo-epithelial elements, are situated superficially in the labra of both upper and lower jaws. The submaxillary glands are located anteriorly and laterally on both sides of the nasal septum. Selective stains justify a classification of them as muco-albuminous cells. The paired sublingual glands are embedded deep in the dermis of the lower jaw. The cells of the secreting acini are true mucous cells.

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AUDIOGENIC SEIZURES IN THE LABORATORY MOUSE

By Hubert Frings and Mable Frings

In a previous report (Frings *et al.*, 1951) the behavior of the laboratory mouse under auditory stress was described. Certain problems arose in that work which seemed to need further investigation. First, the test situation was such that little was learned about the actual seizure itself, since the sound inducing the seizure was turned off as soon as the animal started the seizure sequence by running. Second, the temporal distribution of seizures in populations of laboratory mice tested every day from 15 to 50 days of age was possibly influenced by deaths of susceptible animals which occurred during the earlier days of testing. It seemed advisable to study fully the sequence during seizures in the mice, making no effort to save the animals and to determine, if possible, the real temporal distribution of seizures uninfluenced by deaths of animals during the first few days of testing.

This work was financed in part by the U. S. Air Force, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, under Contract No. AF-33(038) -786 and by the John G. Vogel Memorial Research Fund.

Materials and methods.—Three strains of mice were used in this study—*dba*, Subline 1 (from the market stock of the Jackson Memorial Laboratory); *C-57* black, Subline 6 (likewise from the Jackson Laboratory); and Albino (mongrel stock, called "Swiss", purchased from an animal dealer). The methods for feeding and handling have been described previously (Frings *et al.*, 1951).

The mice were induced to undergo seizures, as in the previous work, by being placed in a sound field at a frequency of 10 Kc and an average sound pressure of 110 db. The sound source was a Western Electric Microphone (Type 633-A), actuated by a Hewlett-Packard

Audio-Oscillator (Type 200-A). The animals were imprisoned in a screen cage (15 x 10 x 10 cm.) during the tests. Cage and microphone were enclosed within a small anechoic chamber to minimize discomfort to the operator.

In the studies on behavior patterns before and during seizures, the mice were exposed to the sound once per day except Sunday for 90 seconds. Contrary to the previous work, the sound was not turned off when the mouse entered the running phase of the seizure, but was left on for the full 90 seconds, regardless of the outcome. This afforded a standard test situation during, as well as before, the seizures. A detailed record was kept of the behavior of mice having seizures and of those not having seizures.

In the study on the distribution of seizures as a function of age, the sound was kept on only until the mouse started the wild running phase of the seizure, and the sound was then turned off in an attempt to save the mouse for further testing and for possible breeding. This procedure resulted in incomplete seizures in most cases. Some mice, however, had full seizures terminating in death. In the previous study, the mice were all tested daily from 15 to 50 days of age. A sizable proportion of the *dba*'s died during the testing period, and these were probably the most susceptible individuals. It was believed, therefore, that the later apparent decrease in seizure susceptibility that was discovered might have been due to the deaths of susceptible mice rather than to a real decrease. To test this idea, it seemed advisable to start the testing of mice at different ages throughout the susceptible period. Thus, a group of *dba* and Albino mice was started at each day of age from 19 to 30 days. The mice to start each day were selected at random by drawing a slip of paper bearing a number from 19 to 30 for each mouse in a litter and starting the mouse on the day of age thus selected.

The results of this experiment showed that, in the experimental set-up used, seizures on the first day of testing were few. Thus the experiment failed to give the desired information. It did, however, raise two questions with respect to the previous study (Frings *et al.*, 1951). In this earlier work, all mice were first tested at 15 days of age and the earliest seizures occurred at 16 or 17 days of age. However, as the present work showed, first day seizures are rare. The first question, therefore, would be whether the previous work did not give misleading information about the age threshold for seizures. Secondly, in the first study, the animals were tested twice per day and in the present study once per day. Since the number of exposures to sound might influence the age at first seizure or the number of seizures, the results of the two experiments might not be comparable. The second question, therefore, would be whether mice tested once per day would differ in seizure incidence from those tested twice per day.

To answer the first question, mice were started at two ages—10 and 15 days of age. Each litter was divided equally between these two by starting the odd-numbered mice at 10 and the even-numbered mice at 15 days of age. To answer the second question, mice were tested, starting at 15 days of age, either once or twice per day, the odd-numbered mice of each litter being tested once and the even-numbered mice twice per day. Testing in these experiments was carried out as in the earlier experiments with the sound being turned off as soon as a seizure started.

Results.—The pre-seizural or non-seizural behavior patterns of mice have been described in detail previously, and the present study merely confirmed these observations. Since, however, the method of recording developed in the previous study and utilized in subsequent studies has proved to be very satisfactory, a description of the technique is submitted here. The behavior of the mice can be classified into certain easily recognized patterns, and we have given symbols to these for recording purposes. The behavior patterns are presented in Table 1, with the symbols used for them, and the percentage of time spent by Albino mice in the different types of behavior. The percentages given in the table for Albinos are almost identical with those for *dba*'s and *C-57*'s. Using the short-hand symbols, it is possible to keep a good record of the behavior of each mouse during testing.

As noted in the previous report, most mice start a seizure from the cringing position. The percentage of time spent in this position as set forth in the table shows clearly that

cringing is the most usual behavior pattern of susceptible mice. Another interesting point appears in the results presented in the table. Cleaning behavior is rare in mice before a seizure, and in these cases usually consists merely of passes at the face ("tics" in the terminology of Chance and Yaxley, 1949). However, cleaning is the second most frequent type of behavior in animals which do not have seizures, and here it is usually business-like and effective. This early led to the belief that an animal which cleaned would not have a seizure in the same testing period. Unfortunately, however, some mice clean before having a seizure, and this supposed criterion of non-susceptibility had to be abandoned.

A detailed study was made of the temporal sequences and behavioral events in over 1000 seizures in the three strains of mice. The seizures were of varying severity. Some mice would merely run wildly about for a time and then stop as if in a cringe. At the other extreme, mice would undergo full convulsions, ending in death. For descriptive purposes, seizures were arbitrarily divided into four types, based on severity. The four types, however,

TABLE 1.—*Behavior patterns of Albino mice during sound treatment, the symbols used to designate the patterns, and percentages of time spent in each behavior type by mice before a seizure (Preseizural) or by mice which did not have a seizure during the test period (Non-seizural).*

BEHAVIOR PATTERN	SYMBOL	PER CENT PRESEIZURAL	PER CENT NON-SEIZURAL
Sitting quietly	Q	Typical of young mice before the sound is turned on	
Jumping (Startle)	J	Typical of all mice as the sound is turned on	
Cringing	C	85	59
Moving	M	2	10
Running	R	1	1
Climbing	Cl	7	7
Cleaning (Grooming)	K	3	16
Scratching	Sc	Rare	Rare
Moving in sidewise, jerky, cringing attitude	H	1	1
Pushing nose through cage bars and biting at bars as if to escape	E	1	6

have intergradations and are not meant as four qualitatively different types. A later conference with workers in other laboratories revealed that this fourfold classification had been used by others as well. The results of the conference will be published elsewhere. The terminology adopted at this conference to standardize descriptions of convulsive behavior in mice is used in this paper.

A seizure may be viewed as occurring in three phases: (1) the preconvulsive phase; (2) the convulsive phase; and (3) the postconvulsive phase. These are arranged in correct temporal sequence. The mice, however, that do not have convulsions may be considered as omitting the second phase.

An invariable part of the preconvulsive phase is the wild running activity. This run starts rather explosively, usually from a cringing position, and is easily distinguished from ordinary running. While the run is wild, it is not uncoordinated, for the mice do not injure themselves by running headlong into barriers. This is designated symbolically by "W" in our records.

In some mice, the run is followed by merely stopping, usually in a cringe, without a convulsion. This type of activity is called a *subconvulsion*, designated symbolically as "S" by us. Recovery is usually rapid and animals do not die as a result of this type of seizure.

Mice that react more violently to the sound undergo convulsions of varying severity. The least severe of the convulsions is the *convulsive spasm*, designated symbolically as "S^{+}" by us. In this type, the animals stop running in a contorted position, often almost over on the side, with the body jerking spasmodically. There are no deaths as a result of this type of seizure. A more severe type of convulsion is the *clonic convulsion*, designated as "S^{*}" by us. In this type, the mice lose coordination, fall over on the side or back and exhibit rapid movements of the legs, as if running. Often the animals flop about in a most alarming fashion as a result of the kicking, and one wonders that they are not injured, but they do not seem to be. In *dba*'s and *C-57*'s deaths in this type of convulsion are rare; in Albinos, in this experiment, 15 per cent of the deaths occurred in this type. The most severe type of convulsion is the *clonic-tonic convulsion*, designated by us as "Ⓢ". In this, the mice roll over uncoordinatedly, after the wild run, kick for a short time as if in a clonic convulsion, then draw the legs against the body and violently thrust them outward in an extreme tonic extension. Respiration ceases as the stiffening occurs, the ears are lowered into the fur and the eyes are closed. The tonic extension is held for a short time, and then the animals either gasp and start to kick, or relax and are dead. Death is the most usual outcome of this type of seizure, and relaxation of the body with erection of the ears and opening of the eyes indicate a fatal outcome.

While these four types can thus be diagnosed for convenience, the classification system is not rigid, and intergrades occur. In a sense, the types of seizures may be looked upon as recognizable points on a behavioral continuum. Thus animals progress, after the wild running phase, to some level of severity, from subconvulsions resembling a cringe to full clonic-tonic convulsions and death. Further, the type as designated above is probably in part determined by the substrate given the mice. It is certain, for instance, that mice which would have severe convulsive spasms in a cage such as was used in these experiments would roll over into clonic seizures in apparatus affording poorer foothold. Further evidence of intergrades can be found in the cases of mice which undergo clonic-tonic seizures, but stiffen only the front legs, holding the back legs against the body. It is because of the occurrence of intergrades, with possible differentiation at least in part dependent upon apparatus, that it seems advisable to consider the seizure as beginning with the wild running phase. This is invariable and easily differentiable. The time elapsing from the turning on of the sound to the start of the wild run is thus designated as the seizural latent period.

The postconvulsive phase varies with the type of seizure. Following a subconvulsion or a convulsive spasm the animal usually returns to normal action within 10 to 30 seconds. Both of these types of seizures may be followed by later seizures in the same testing period. In one-fourth of all the tests in which seizures occurred there were two or more seizures. For Albinos, multiple seizures ranged in number from two to six in a 90-second period, most of the cases being two, with only one case of six. In *dba*'s, there were no more than two seizures per test period, and in *C-57*'s, only two or three, with two seizures the more numerous.

The postconvulsive phases for clonic and clonic-tonic types of convulsions are longer and difficult to interpret from mere observation. Usually the first evidence of return to normalcy in clonic convulsions is regaining the feet, but this is followed variously by running, climbing, moving in circles, or by cringing. It is difficult to decide just when any of these become the normal type. The first evidence of recovery following a clonic-tonic convulsion is a deep gasp, usually accompanied by kicking, occurring about 10 to 15 seconds after respiration has ceased. This is succeeded by feeble kicking and rapid, shallow breathing, while the animal is on its side or back. After a variable period of this, usually 15 to 30 seconds, the animal rolls onto the feet and stands quietly for some time, finally moving about. Just when the animal is to be considered as normal in this sequence—if, indeed, the animal is normal for some time afterward, possibly hours—is uncertain. A clonic convulsion may rarely be followed by a second seizure, but a clonic-tonic type is not.

The occurrence and sequences in the seizure types were studied for the three strains. Qualitatively no clear-cut differences appeared among the three. Quantitative data on the

occurrence of the different types of seizures, deaths during seizures, seizural latent periods, and other aspects of the seizure patterns are presented in Table 2.

TABLE 2.—*Quantitative data on seizures for three strains of mice*

	ALBINO	*dba*	C—57
Number of litters	20	12	4
Number of mice	134	59	31
Number of tests	3029	341	454
Number of seizures	1052	156	183
Types of seizures			
Subconvulsions	52%	24%	39%
Convulsive spasms	17%	25%	38%
Clonic convulsions	19%	16.5%	10%
Clonic-tonic convulsions (Non-fatal)	4.5%	0%	3%
Clonic-tonic convulsions (Fatal)	7.5%	34.5%	9%
Deaths in seizures	77 (57%)	54 (92%)	16 (52%)
Age at death			
Range	17–42 days	16–22 days	18–27 days
Mean ± Standard error	23.1 ± 0.5 days	18.3 ± 0.2 days	21.6 ± 0.7 days
Seizural latent period			
Range	2–88 sec.	6–81 sec.	6–85 sec.
Mean ± Standard error	21.0 ± 0.4 sec.	26.6 ± 1.6 sec.	26.1 ± 0.7 sec.
Median	16.3 sec.	20.1 sec.	21.2 sec.
Wild running periods			
Range	1–24 sec.	2–16 sec.	1–13 sec.
Mean ± Standard error	5.9 ± 0.1 sec.	5.3 ± 0.2 sec.	6.5 ± 0.2 sec.
Sequences in fatal clonic-tonic convulsions			
Duration of clonic phase			
Range	1–12 sec.	1–5 sec.	1–5 sec.
Mean ± Standard error	4.6 ± 0.21 sec.	2.7 ± 0.17 sec.	2.3 ± 0.3 sec.
Duration of tonic phase			
Range	6–27 sec.	6–18 sec.	13–30 sec.
Mean ± Standard error	13.5 ± 0.5 sec.	12.3 ± 0.4 sec.	20.2 ± 1.3 sec.
Age at first seizure			
Range	15–33 days	16–22 days	16–21 days
Mean ± Standard error	20.0 ± 0.3 days	17.2 ± 0.1 days	18.3 ± 0.2 days
No. of mice without a seizure	4	2	0

These figures clearly show that *dba*'s are most susceptible to fatal clonic-tonic convulsions. Albinos and *C-57*'s seem to substitute less violent types of seizure and thus to survive. While none of the *dba*'s survived a clonic-tonic seizure, however, Albinos and *C-57*'s

were capable of doing this. The age at death is significantly lower for *dba*'s than for *C-57*'s and Albinos. The latent period difference between Albinos and the other two strains is due to the fact that over half of the Albinos used in these experiments were offspring of parents selected for high seizure incidence. Other work in this laboratory indicates that the latent period decreases strikingly as the seizure susceptibility increases. It is also worthy of note that the clonic phase of clonic-tonic convulsions for Albinos is longer than that for the other two strains. Albinos seem to be more deliberate in drawing in and extending the legs. Another interesting strain difference is the very significantly longer tonic period in fatal seizures for *C-57*'s than for the other two strains. This probably reflects a superior ability to withstand anoxia during this phase of the convulsion. An attempt was made to correlate the duration of the wild running phase with the type of subsequent seizure, but no differences were found in running times preceding the different types of seizures.

In our previous report, it was stated that the *dba*'s seemed to have seizures at a younger age than the other two strains. This was established as significant in this study. The order of appearance of seizures with respect to age was *dba*'s earliest, *C-57*'s intermediate, and Albinos latest. The later distribution of seizure susceptibility with respect to age was not studied in detail, because of the large proportion of the animals which died. For Albinos and *C-57*'s, of which nearly one-half lived, the distribution checked that described previously. All three strains are obviously susceptible to seizures, the interstrain differences being in age distribution. For instance, the *C-57* strain, which has been reported previously as of low susceptibility (Hall, 1947; Witt and Hall, 1949), was the only strain tested which had 100 per cent of the animals with seizures.

The experiments designed to discover the temporal distribution of seizure susceptibility, using animals started at different ages, gave scant information on this subject. Out of 98 Albinos started from 19–30 days of age, only three had seizures on the first testing day. Out of 102 *dba*'s similarly tested, only 14 had first day seizures. Most of these occurred in animals started on 20–24 days of age, thus checking the previous study which showed a peak in susceptibility to seizures during these days.

The results of the experiment in which animals were started at 10 or 15 days of age showed that, for Albinos, the earlier start did not bring about earlier seizures. Seventy mice were tested, the mean age of first seizure for those started at 10 days of age was 21.4 ± 0.72, for those started at 15 days of age it was 20.8 ± 0.67. Only 8 *dba*'s were tested, but there was some evidence that they could have seizures earlier in life when started at 10 than when started at 15 days of age.

The experiment in which animals tested once per day were compared with those tested twice per day showed no difference in age of first seizure or in percentage of animals having seizures each day. In all, 37 mice were used in this experiment. As noted previously, at ages when they were most susceptible, mice had seizures twice per day when tested thus. This, naturally, involved double jeopardy for the mice, but strangely no more died in seizure than when tested only once per day. This is probably a tribute to the skill of the testers, however, rather than an indication that the seizures were less severe.

Discussion and conclusions.—The terminology used in this paper to describe seizures is that adopted at the conference mentioned above. It differs only in detail from that used by Chance and Yaxley (1949) and Watson (1939) and these differences are due to the differences between *Peromyscus* used by Chance and Yaxley and by Watson, and *Mus* used by the workers at the Bar Harbor Conference.

The similarity between the seizures observed by us and those observed by other workers (Hall, 1947; Ginsburg *et al.*, 1951) is apparent. In general, this work checks that of the previous students of seizures in mice, with the exception that we report *C-57* black mice as distinctly seizure-susceptible if tested before 30 days of age. The *dba* mice, however, clearly are most susceptible to deaths in

seizure. The temporal distribution of seizures for the three strains studied in this work was found, where determined, to be like that previously described (Frings *et al.*, 1951).

At the present time, there seems to be no reason to regard the four types of seizures as separate entities. It appears that, following the wild running phase, the severity of seizure depends upon a number of factors, the seizure developing through the less severe stages (subconvulsion, convulsive spasms) to the more severe (clonic and clonic-tonic convulsions). The factors involved in the case of a given mouse seem to be, at least: (1) its innate susceptibility as determined by the genetic background, (2) the degree of stimulation, (3) environmental effects as yet unassessed, and (4) physiological factors as yet unassessed. That the degree of stimulation is important is shown by the fact that, when the sound is turned off as soon as the wild run starts, most mice can be saved for further testing, whereas, when the sound is left on, most of the mice die. This suggests that the mechanism bringing about seizures is not entirely physiological, but may be in the nature of a noise-fright reaction (Stainbrook, 1947).

It is interesting to compare the results of our tests, in which mice were started at various ages, with those reported by Ginsburg *et al.* (1947, 1951) and Vicari (1947). These workers report seizures in a high percentage of cases for *dba*'s on the first day of testing. They, however, use the bell-tub technique, as described by Hall (1947). The discrepancy between their results and ours is probably due to the fact that, in a tub to which a ringing bell is attached, mice are subjected to complex sounds, as against our simple tone, and also to vibrations through the feet. Since the sound pressure in the tub used by Ginsburg *et al.* (1951) is only 100 db., and our sound pressure is 110 db., the difference is not due to higher sound pressure in the tub. Thus, the other factors—tonal complexity or vibration —must be involved.

The results of the experiment in which the animals were started in testing earlier than 15 days of age show that seizures require a certain level of development of the neuro-muscular system. It is amusing to see mice of about 13 days of age moving about with eyes closed looking as if they would break into a run, but totally unable to accomplish the feat. A few days later, on the feet with eyes open, the same mice exhibit typical seizures. The age range of 16 to 25 days would seem to be very critical for the development of seizure susceptibility, with *dba*'s starting a little earlier than the other two strains tested.

Finally, the results of the experiment in which mice were tested once or twice per day show that, so far as economy of time and reduction of risk to the mice are concerned, testing once per day is better.

Summary.—Seizures were induced in mice of three strains (*dba*, *C-57*, and Albino) by subjection to sound at 10 kc. frequency and 110 db. average sound pressure, and the behavior of mice thus treated was studied in detail. Four types of seizure, on the basis of severity, can be distinguished, but intergrades are found. The most violent type results in death, and *dba* mice were found most susceptible to this type. Most mice do not have seizures on the first testing day, nor before 16 days of age. There were few interstrain differences in seizural behavior, except for the distribution with respect to age.

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THE WATER RAT IN THE PLEISTOCENE OF TEXAS

BY GRAYSON E. MEADE

The Florida water rat or round-tailed muskrat, *Neofiber*, is a small bog-inhabiting rodent, intermediate in size and habits between the common meadow vole and the aquatic muskrat. *Neofiber* lives only in Florida and Georgia where by preference it inhabits the swamp areas that have become so completely choked with aquatic plants that little open water remains. In contrast, the true muskrat seeks the open water of streams, ponds, or marshes. *Neofiber* is reported to be strictly herbivorous in food habits, feeding mostly on roots and grasses, while the muskrat feeds upon both aquatic plants and occasionally such animals as fish, clams, and salamanders.

Fossil remains of *Neofiber* have until recently been known only from the area of its present range. Its occurrence in Pleistocene deposits far removed geographically from its present range is of considerable interest and possibly of some significance both in regard to some of the causal factors in expansion and contraction of range of mammalian species and in the interpretation of climatic conditions. If the premise is permissible that the Pleistocene habitat of *Neofiber* was essentially similar to its present day habitat, then certain conclusions may be drawn concerning the climatic conditions which prevailed in parts of Texas and Kansas during that part of the Pleistocene represented by the deposits containing fossil remains of *Neofiber*.

I wish to express my sincere thanks to Dr. E. H. Sellards for permission to

study the fossil material and to the Department of Zoology of the Chicago Natural History Museum for the privilege of studying their collection of recent material of *Neofiber alleni*. The drawings are by Hal Story, staff artist of the Texas Memorial Museum.

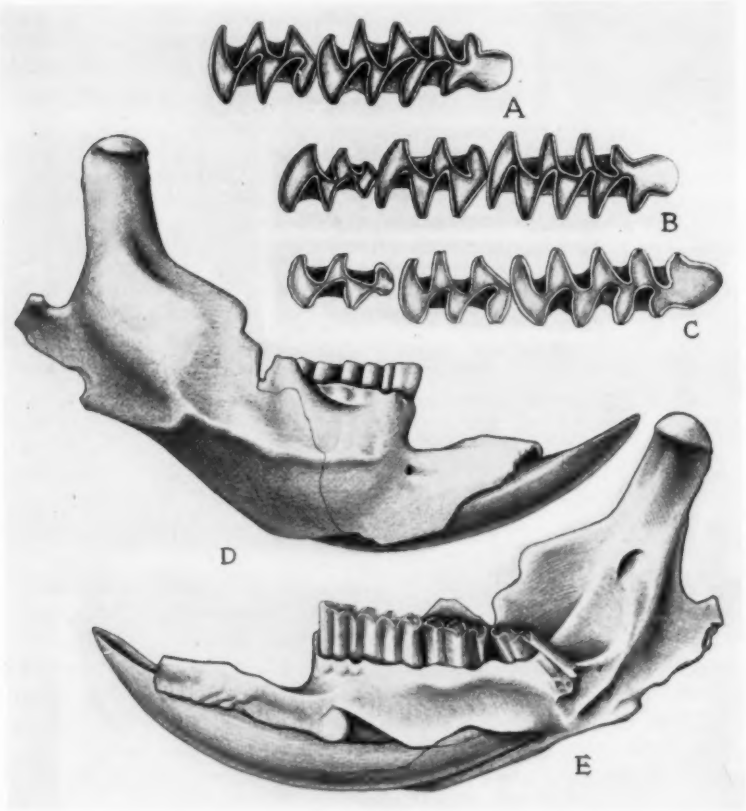

PLATE I

Neofiber leonardi Hibbard. A, right M_1–M_2, No. 882–1, crown view, × 5½; B, left M_1–M_3, No. 882–3, crown view, × 5½; C, right M_1–M_3, No. 882–2, crown view, × 5½; D, right ramus, No. 882–2, labial view, × 2¾; E, right ramus, lingual view, × 2¾; specimens in the Texas Memorial Museum.

Neofiber leonardi Hibbard

Material.—Texas Memorial Museum Nos. 882–1, 882–2, right rami, and 882–3, left ramus, and a number of partial rami and isolated teeth (Pl. I).

Horizon and locality.—Middle Pleistocene, about five miles north of Slaton, Lubbock County, Texas, on the W. E. Smart Ranch, north side of Yellowhouse Canyon. The locality is known as the Slaton quarry, and the fauna may provisionally be called the Slaton fauna.

Diagnosis.—Hibbard (Univ. Kan. Sci. Bull., 29: 235–47, 1943) "Larger than *Neofiber alleni nigrescens* Howell, with external reëntrant angles broader and more forwardly directed."

Additional diagnosis.—The type of *Neofiber leonardi* consists of a right M_1; the paratype of a left M_1. Inasmuch as some of the Texas specimens contain the complete lower dentition it is now possible to give a more nearly complete diagnosis and description of the species.

Alternating triangles slightly more compressed antero-posteriorly, with more angular apices, and with a correspondingly greater antero-posterior width of the reëntrant angles than in *Neofiber alleni alleni*. Antero-external column of M_3 better developed than in the modern species. Size near that of *Neofiber alleni alleni*.

Measurements.—Neofiber leonardi, No. 882-3: length of M_1–M_3 inclusive, 10.9 mm.; length of M_1, 5.6; length of M_2, 2.9; length of M_3, 2.7.

Description.—The ramus, No. 882-3, is that of a young adult. The teeth are hypsodont, non-rooted, and with the reëntrant angles partially filled with cement. The amount of cement filling is notably less than in that of the type specimen, but this is an age characteristic. In the study of a large number of specimens of *Neofiber alleni alleni* it was observed that there was great variation in the amount of cement filling, ranging from a complete absence in very young individuals to an essentially complete filling of the reëntrant angles in old individuals.

The greatest contrast to be noted between the Texas specimens and the Kansas specimens is in the construction of the anterior loop of M_1. The postero-external portion of the loop is somewhat more concave while the internal face has a more pronounced vertical groove than has either the type or the paratype. These differences, however, are strictly attributable to individual variation, for much greater differences were observed in the construction of the anterior loop on modern specimens. In some the anterior loop is bulbous as in the fossil forms, with a great variation in the depth of the grooves, while in others the anterior loop is quite triangular in shape and devoid of vertical grooves.

All the lower molars in the fossil specimen are clearly distinguishable from the teeth of the modern species in possessing triangles which are narrower antero-posteriorly with more angular apices, and in having broader reëntrant angles.

The antero-external column of M_3 is fairly well developed, whereas in *Neofiber alleni* it is greatly reduced. In this respect the fossil form appears to be structurally closer to *Ondatra* than does the living species.

Discussion.—Evidence does not indicate whether *Neofiber* existed contemporaneously in the Plains region and in Florida during the Pleistocene. In Florida the fossil species occurs in deposits of late Pleistocene age (Sellards, 8th Rept. Fla. State Geol. Surv., 1916), whereas those from the Plains region are from deposits of middle Pleistocene age. Thus during the Pleistocene the genus may have had a range extending from Florida to the Plains region; this range becoming progressively more restricted through the later Pleistocene and Recent. Or the genus may have retreated from its Plains environment, reaching Florida in the late Pleistocene and surviving today only in the most favorable localities.

In Florida and Georgia *Neofiber* has an exceedingly restricted habitat range and, for some unknown reason, does not now inhabit other favorable areas in the South. However, it is extremely unlikely that *Neofiber* could now survive in the southern High Plains region under the present day rather arid climatic conditions which produce a paucity of bogs. It may be assumed, therefore, that during that part of the middle Pleistocene when *Neofiber* was living in Kansas and Texas the climate was considerably more humid in these areas than at present. An alternative, but less likely, interpretation is that during the Pleistocene *Neofiber* was adapted to a greater range of climatic and environmental conditions than it can now tolerate.

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NOTES ON THE PYGMY MOUSE (*BAIOMYS*), WITH DESCRIPTION OF A NEW SUBSPECIES FROM MÉXICO

By Emmet T. Hooper

The geographic ranges of *Baiomys taylori* and *B. musculus* are for the most part complementary. That of *taylori* extends from southeastern Arizona and eastern Texas south to Colima and west-central Veracruz. Some marginal occurrences known to me from published records or from specimens in the University of Michigan Museum of Zoology follow: At north, vicinity of: Hereford, Cochise County, Arizona; El Saúz, Chihuahua; Zarca, Durango; Monterrey, Nuevo León; San Antonio, Bexar County, and La Belle, Jefferson County, Texas. At south, vicinity of: Pujal, San Luis Potosí; Acultzingo, Veracruz; México, Distrito Federal; Apatzingán, Michoacán; Colima, Colima; and La Resolana, Jalisco. The range of *B. musculus* lies mostly south of the range of *B. taylori*. It extends from western Nicaragua northwest through El Salvador, southern Honduras and Guatemala to the escarpment of the Mesa Central of México; there it bifurcates around those highlands, one arm extending to central Veracruz, the other reaching at least to western Jalisco. Two southern marginal records are the vicinity of Matagalpa and of San Rafael del Norte, Nicaragua. Some northern occurrences are the vicinity of: Jalapa and Plan del Río, Veracruz; Tepanco and Piaxtla, Puebla; Tepoztlán, Morelos; Tzitzio and Tacámbaro, Michoacán; and San Gabriel and Ameca, Jalisco. Osgood (N. Amer. Fauna, No. 28, p. 258, 1909) referred specimens from Culiacán, Sinaloa, and Valparaíso, Zacatecas, to *B. musculus*. However, apparently he suspected that they might be examples of *B. taylori*; he noted that their skulls were "somewhat peculiar." The specimens should be re-examined.

Because their ranges are chiefly complementary and because size is the principal differential character ascribed to the forms (Osgood, *op. cit.*), one might readily suspect that the two interbreed and thus may be one species instead of two. There is no evidence that they interbreed, however, unless the aforementioned specimens of peculiar structure from Culiacán and Valparaíso be hybrids. Examples of each of the species have been collected at each of several localities. In each instance the characters of the species are sharply segregated, apparently evidencing complete reproductive isolation of the two forms.

In the southern United States and northern México *B. taylori* occurs on the lowlands of both coasts as well as on the intervening Mexican Plateau. At the latitudes in central México where its range meets that of *B. musculus*, however, *taylori* is typically the form of the arid temperate highlands and *musculus* is predominant in the adjoining arid tropical lowlands. In this border zone that fringes the Mesa Central, the ranges overlap and interdigitate; peninsulas of the range of *musculus* extend onto the rim of the Plateau and the range of *taylori* projects finger-like into lowlands.

Following are localities at which both species are known to occur: Colima, Colima (Osgood, *ibid.*), and San Gabriel, La Resolana, and Ameca, Jalisco. At each of the three Jaliscan localities our field party from the Museum of Zoology

collected examples of each species a few feet apart in the same trap line. Insofar as we could determine the two species were not ecologically segregated. To judge from our collections, however, there is a great disparity in population sizes of each species in those areas. The series from San Gabriel contains one specimen of *taylori* and 33 examples of *musculus*. In the sample from La Resolana the ratio is 25 *taylori* to 6 *musculus* and in that from Ameca 35 *taylori* to 6 *musculus*. These ratios may be taken as loose estimates of the number of each species that came to trap. Although at each locality some specimens were discarded for one reason or another (broken skulls, immaturity, etc.), we did not consciously discriminate between species in selecting specimens for our permanent collections.

In the zone of overlap of their ranges in Jalisco the two species are distinguishable in size and coloration. At each locality where both species were sampled the specimens of *musculus* are grayer, less brownish, dorsally than are the examples of *taylori*. Distinctions in color are apparent when the specimens are laid out on the laboratory table, but they are not always easily recognized in the field. Length of hind foot and length of ear are useful in identifying single individuals, but neither of those measurements alone is always absolutely diagnostic. In combination they identify almost all of the specimens at hand (Fig. 1), which includes both young and old individuals of each species. Size of the cranium is particularly diagnostic. The specimens of *musculus* are larger than those of *taylori*. In the range in cranial dimensions established by the present series of each species there is no overlap in cranial length and but slight overlap in zygomatic breadth (Fig. 2).

The crania of the specimens of *musculus* from Jalisco average larger than do those from any other area whence samples of *musculus* are at hand. The difference in cranial size between the two species, therefore, may be emphasized there. Nonetheless a similar disparity is evident in samples from other localities in the zone of overlap and interdigitation of the species. Samples of *musculus* from Tzitzio, Tepoztlán, and Tepanco compared, respectively, with samples of *taylori* from Apatzingán, Mexico City, and Acultzingo are cases in point.

Variation in pelage coloration in *Baiomys musculus* are not well understood and it is unlikely that they will be appreciated fully until the genetics of coloration in the species has been worked out. In addition to the usual variations which appear to be related to wear and to pelage replacement there are two sorts of variations which warrant especial mention. One pertains to white spotting or flecking on the upper parts, the other to intensity of pigmentation. In almost every sample of five or more specimens the upper parts of some individuals are flecked with white. In these small white areas the hairs are entirely white, apparently devoid of pigment. These white hairs may represent regrowth over an injured spot. Their cause is yet unexplained. Also in most samples there are a few individuals that are strikingly paler or darker than the average of their sample. These extremes do not appear to represent color phases of the sort seen in *Peromyscus* (Blair, Contrib. Lab. Vert. Genetics Univ. Mich., No. 35, 1947). Buffy orange pigments, absent in the gray phase of *Peromyscus*,

appear to be present in both dark and pale specimens of *Baiomys musculus*. A principal difference between the extremes appears to be in *intensity* of all pigments—the buffy orange and the blackish—in both the cover and guard hairs. Multiple factors that affect intensity of pigmentation could account for the light and dark extremes and the essentially complete series of intermediate stages represented in the samples.

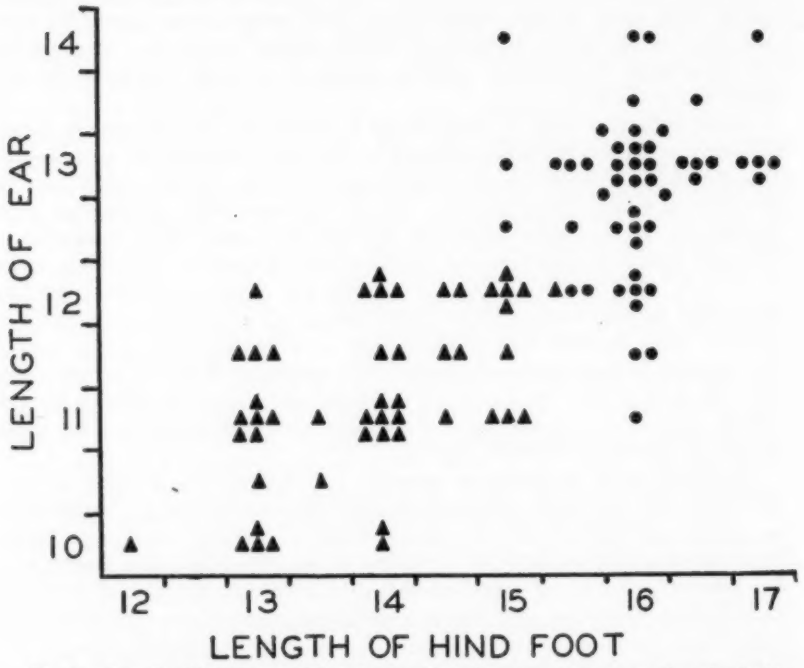
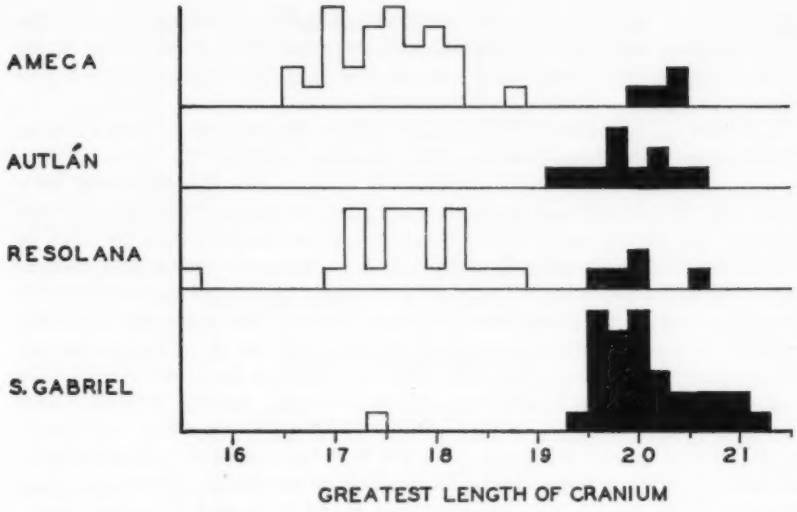


FIG. 1.—Length of hind foot and length of ear (mm.), measured from notch on fresh skin, of 49 specimens of *Baiomys musculus* (dots) and 49 specimens of *B. taylori* (triangles) from western Jalisco, México.

Pelage coloration in *Baiomys musculus* varies geographically, as pointed out by Osgood (*op. cit.*). When the samples at hand from México are arranged geographically on the laboratory table, I divide them into 4 groups on the basis of coloration. The most intensely pigmented specimens are from the coastal strip of southern Chiapas (Mapastepec and Pijijiapan) and from the mountains of eastern Chiapas (Las Margaritas). These apparently are typical of the race *nigrescens*. They are characterized by dark reddish brown upper parts. The long basal bands of the hairs are plumbeous black. The underparts are pale pinkish-buff; the buffy tips of the hairs do not obscure the plumbeous basal parts. The ears are fuscous. The tail is blackish and monocolor. The



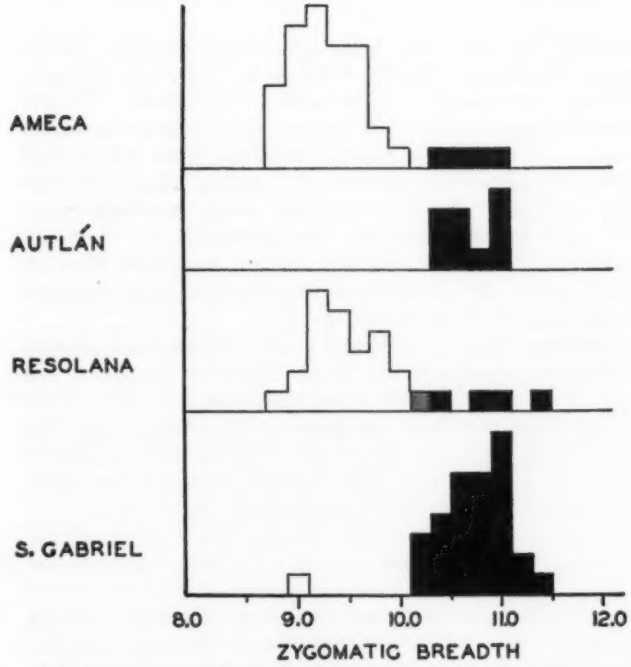


FIG. 2.—Ranges in length of cranium and zygomatic breadth (mm.) of 4 samples each of *Baiomys musculus* (solid squares) and *B. taylori* (open squares) from western Jalisco.

upper surfaces of the forefeet and hind feet are lightly or strongly dusky. The most intensely pigmented individuals are predominantly sooty dorsally. In the juvenal pelage the upper parts are blackish and the underparts are dull plumbeous, lightly washed with white or cinnamon.

A second group includes the specimens from central and western Chiapas (Bochil, Tuxtla Gutiérrez, Ocozocoautla, Cintalapa and Villa Flores) and eastern Oaxaca (Reforma). In coloration these are between the aforementioned dark series and the paler groups from more northerly localities. They are also dark dorsally, but they average distinctly paler and less blackish than do those of the first group. The basal bands of the hairs are not as intensely black. Moreover there is a higher percentage of moderate to lightly pigmented specimens in this group, particularly in the segment of it from Chiapas. The underparts are warm pinkish cinnamon, distinctly more buffy (not as pale) on the average than are the specimens of the first group; the buffy hue tends to be concentrated in the pectoral region. The tail is paler ventrally than dorsally, tending to be distinctly bicolor. The upper surfaces of the forefeet and hind feet are white, not dusky. In the juvenal pelage the upper parts are a mixture of black and cinnamon; the mass effect is a grayish brown. The underparts are whitish. Specimens from Veracruz (Plan del Río and Presidio) well might be included in this group. They may be very slightly paler dorsally, but the difference is subtle, if real at all.

A third group includes the specimens from central and southern Oaxaca (Tehuantepec, Nejapa, Miahuatlán, Ejutla, Sola de la Vega, and Oaxaca), Guerrero (Chilpancingo, Zihuatanejo, Teloloapan, and Iguala), Morelos (Tepoztlán), southern Michoacán (Tzitzio), Jalisco (San Gabriel, Resolana, Chamela Bay, Autlán, and Ameca), and possibly Veracruz (Plan del Río and Presidio). To this group the subspecific name *musculus* applies. These specimens are generally similar to those of the aforementioned group, but their upper parts average slightly paler and more reddish. The underparts vary from cinnamon to pale pinkish cinnamon. The feet and tail are similar to those in group two. The juvenal pelage also is slightly less blackish and more rufescent dorsally than in the specimens of the second group.

Specimens from northern Oaxaca (Teotitlán) and southeastern Puebla (Tehuacán and Tepanco) constitute a fourth group. These are the palest. The upper parts are ochraceous-buff; the black hairs contribute less to the mass effect of the upper parts than they do in specimens of the other groups. The underparts are white or pale buffy; the pale distal bands of the hairs mostly obscure the plumbeous basal bands. The upper surfaces of the feet are white, the ears pale, and the tail bicolor, fuscous above and white below.

Variations in coloration and size apparently are distributed independently in the species. The palest and the darkest samples are closely similar in size of body and skull. Figure 3 illustrates variations in breadth of the brain case in the samples. In three other diagrams that were constructed (one each for length of incisive foramina, palate, and nasals) the distribution of the means is similar to that in Fig. 3. Largest size obtains in the samples from Jalisco. Size tends to

decrease progressively toward the south, attaining a minimum in the samples from the Isthmus of Tehuantepec. The means of the Isthmus samples are all

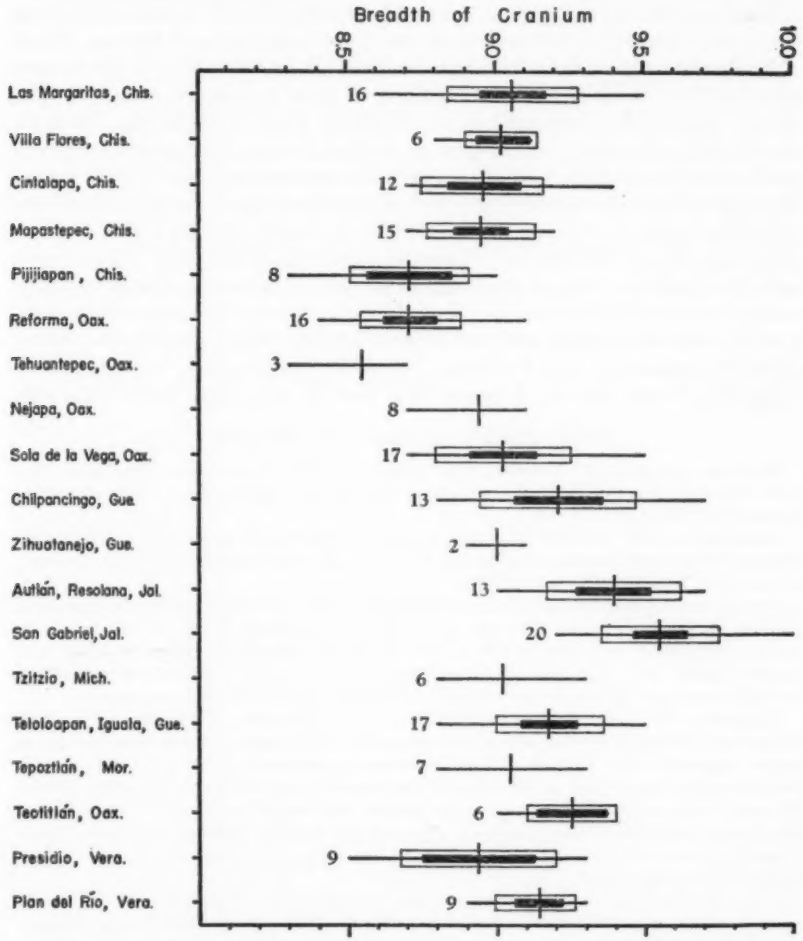


FIG. 3.—Statistical analysis of breadth of cranium (mm.) in samples of *Baiomys musculus* from México. Horizontal lines represent range; cross bars indicate means. Rectangles mark one standard deviation each side of the mean; horizontal black bars define two standard errors each side of the mean. Numerals indicate numbers of specimens.

significantly smaller than those from Guerrero and Jalisco. In the samples from localities south of the Isthmus the means again are larger. The calculated mean brain case breadth of each of the intensely pigmented samples from the Pacific

coast (Mapastepec) and from the interior of Chiapas (Cintalapa, Villa Flores, and Las Margaritas) is similar to the mean of each of the moderately dark samples from Veracruz and the pale samples from Puebla and northern Oaxaca.

These geographic variations in size and coloration largely accord with those observed by Osgood in other specimens from the same region of México. (None of the specimens come from the range ascribed to *B. m. brunneus*.) In the present material there is basis for the recognition of three geographic races: (1) The deeply pigmented, moderately small *nigrescens* which inhabits the southern coastal and eastern parts of Chiapas. In western Chiapas and eastern Oaxaca it grades into (2) the paler form *musculus* which apparently is significantly larger than *nigrescens* in the northwestern part of its range, but not in its northeastern or southern parts. In the series at hand I refer the specimens from eastern Oaxaca (Reforma) and all localities in Chiapas to *nigrescens*. Those from Tehuantepec and other localities west of the Isthmus are labeled *musculus*. The geographic range of *musculus* largely encircles that of (3), a series of extremely pale populations in northern Oaxaca and southeastern Puebla. These populations, represented by specimens from Teotitlán, Tehuacán, and Tepanco, warrant formal recognition, in my opinion. I suggest that they be referred to under the name

Baiomys musculus infernatis, new subspecies

Holotype.—Adult male (all teeth worn), skin and skull; Univ. Mich. Mus. Zool. No. 91497; México, Oaxaca, Teotitlán; collected 24 February 1947 by Helmuth O. Wagner; original No. 2702.

Distribution.—The arid interior basin drained by the Salado and Quiotepec rivers in northern Oaxaca and southeastern Puebla. Known range from Teotitlán, 3100 feet, Oaxaca, northwest to Tepanco, 6000 feet, Puebla.

Comparisons.—Compared with *musculus* (topotypes of *infernatis;* specimens of *musculus* from southwestern Jalisco): Averaging smaller in total length, length of tail, and most cranial dimensions; with significantly smaller means for breadth of zygomatic plate and length of palate, and a significantly greater mean length of incisive foramina. Paler dorsally, the buffy hues more yellowish (less pinkish). Plumbeous basal bands of hairs paler.

Compared with *nigrescens* (topotypes of *infernatis;* specimens of *nigrescens* from Las Margaritas, Chiapas): Similar in size, but apparently with longer incisive foramina and a broader zygomatic plate; in each of those measurements the mean of the series of *infernatis* is significantly larger than is the mean of the sample from Chiapas. Coloration widely different in the two races. Upper parts pale grayish buff in *infernatis*, compared with reddish brown; underparts more intensely buffy, on the average, than in *nigrescens;* basal plumbeous bands much paler. Upper surfaces of feet white, not faintly or strongly dusky; tail bicolor, not monocolor.

B. m. brunneus is said to be darker and more brownish dorsally than is *musculus* and is reported to have somewhat shorter nasals than that race (Osgood, *op. cit.*). In the samples at hand the nasals of *infernatis* are not significantly shorter than those of *musculus*. Moreover the samples of *infernatis* are distinctly paler dorsally than are those of *musculus*. Accordingly, *infernatis* and *brunneus* must be even more dissimilar than are *infernatis* and *musculus*. I have seen no specimens from within the range ascribed to *brunneus*.

Color.—Fresh pelage of molting specimen from Teotitlán: Dorsum and sides pale grayish buff; cover hairs Pinkish Buff distally, Neutral Gray basally (capitalized color terms from Ridgway, Color Standards and Color Nomenclature, 1912); guard hairs Neutral Gray basally and black terminally, the black scarcely obscuring the underlying buffy bands of the cover hairs. Throat white, the remaining underparts Neutral Gray, washed with Pale

Pinkish Buff or Pinkish Buff. Forefeet and hind feet white dorsally. Lateral surfaces of ankles and wrists dusky, the remainder white. Tail drab or dusky above and white below, except near tip where it is dusky all around.

Measurements.—Averages and extremes in millimeters of 7 specimens (all with worn teeth) from Teotitlán: Total length, 114 (106–122); tail vertebrae, 44 (41–46); hind foot, 14 (13–16); ear, from notch, 12 (12–13). Greatest length of skull, 20.1 (19.7–20.4); zygomatic breadth, 10.4 (10.2–10.6); breadth of cranium (greatest breadth above zygomatic processes of squamosals), 9.3 (9.0–9.4); interorbital breadth, 4.0 (3.9–4.1); greatest length of nasals, 7.6 (7.2–8.0); least breadth of zygomatic plate, 1.6 (1.5–1.8); length of palate, 2.6 (2.3–2.8); length of incisive foramina, 4.8 (4.4–5.6); alveolar length of molar row, 3.2 (3.1–3.3).

Remarks.—Apparently the populations of most of the rodent species that inhabit the arid basin in which Teotitlán and Tehuacán are situated are characterized by pale pelage coloration. All samples at hand are pale. These represent the species *Dipodomys phillipsi*, *Liomys irroratus*, *Reithrodontomys fulvescens*, *Baiomys musculus*, *Peromyscus leucopus*, *P. melanophrys*, and *P. mekisturus*, *Oryzomys couesi*, *Sigmodon hispidus*, *Neotoma torquata* (?), and *Neotoma* (*Hodomys*) *vetulus*. The recognition of *B. m. infernatis* adds one more name to the list of pale forms which may be restricted to the basin. Others are *Dipodomys phillipsi oaxacae*, *Liomys irroratus torridus*, and *Reithrodontomys fulvescens infernatis*.

Specimens examined.—Three hundred and fifty-nine from localities in México as follows: *B. m. infernatis*. OAXACA: Teotitlán, 3100 ft., 12. PUEBLA: Tehuacán, 5400 ft., 3; Tepanco, 6000 ft., 3. *B. m. musculus*. GUERRERO: vicinity of Chilpancingo, 4000 ft., 22; Iguala, 2400 ft., 5; Teloloapan, 5400 ft., 20; Zihuatanejo Bay, near sea level, 4. JALISCO: 10 mi. S Ameca, 5800 ft., 1; 6–7 mi. W Ameca, 4000–4300 ft., 5; 4 mi. NE Autlán, 3000 ft., 11; Sierra de Autlán, 5000 ft., 2; Chamela Bay, near sea level, 1; 2 mi. N La Resolana, 1200 ft., 6. MICHOACÁN: 12 mi. (by road) S Tzitzio, 3400 ft., 6. MORELOS: 1 mi. W Tepoztlán, 6000 ft., 9. OAXACA: Ejutla, 4700 ft., 22; Miahuatlán, 5000 ft., 12; Nejapa, 1900 ft., 12; Oaxaca, 5000 ft., 7; Sola de la Vega, 5000 ft., 26; Tehuantepec, 100 ft., 9. VERACRUZ: 20 mi. SE Jalapa, vicinity of Plan del Río, 1000 ft., 14; 4 mi. NE Motzorongo, Presidio, 1000 ft., 15. *B. m. nigrescens*. CHIAPAS: Bochil, 4300 ft., 7; Cintalapa, 1700 ft., 18; Mapastepec, 200 ft., 25; 16 mi. E Comitán, Las Margaritas, 4000 ft., 24; Ocozocoautla, 2300 ft., 10; Pijijiapan, 50 ft., 7; 7 mi. W Tuxtla Gutiérrez, 1800 ft., 4; Villa Flores, 2000 ft., 7. OAXACA: Reforma, 500 ft. (?), 30.

University of Michigan Museum of Zoology, Ann Arbor, Michigan. Received May 7, 1951.

A NEW BEAVER, AND ASSOCIATED VERTEBRATES, FROM THE PLEISTOCENE OF OKLAHOMA

By George C. Rinker and Claude W. Hibbard

Pleistocene deposits in Beaver County, Oklahoma, have been studied intermittently by Claude W. Hibbard and field associates since 1940, in co-operation with Robert H. Dott, Director of the Oklahoma Geological Survey; Stuart L. Schoff, Geologist of the United States Geological Survey; and J. Willis Stovall, Director of the University of Oklahoma Museum. The financial support accorded the junior author by the Faculty Research Fund of the University of Michigan has made possible the illustration of the paper.

The new beaver, and associated vertebrates, here reported were taken in the vicinity of the Gate ash pit, 4½ miles north and nearly one mile west of Gate, Oklahoma. The fossils were recovered while trying to locate the molluscan fauna reported by Frye, Swineford, and Leonard (1948, p. 11, table 1) and Leonard (1950, p. 41, fig. 4) as occurring in the silts below the Pearlette ash in the Gate ash pit (Beaver County, Oklahoma, Loc. 38).

The Gate ash pit and vicinity had been intensively studied by Hibbard and party in the summer of 1942. No vertebrates and only unidentifiable fragmentary mollusk remains were found in the silts below the ash at the pit. Above the Pearlette ash there occurs a deposit of silt, clay, and reworked ash containing abundant remains of mollusks. On July 23, 1942, Hibbard, Rinker, Henry Hildebrand, and Jack Twente removed over a ton of the matrix containing abundant mollusks above the Pearlette ash in hopes of finding a vertebrate fauna comparable to the Borchers fauna of Meade County, Kansas. Only isolated fish remains were found associated with the mollusks. The mollusks were placed in the University of Kansas Museum. A. Byron Leonard later joined our party and was taken, August 18, to see the snail horizon above the ash at the pit.

An intensive study was made of the area in the summers of 1950 and 1951. Only a few fragmentary pieces of mollusks and a catfish spine were recovered from the silts below the ash at the pit. Two sacks of matrix removed from the reworked ash horizon at the same locality as in 1942 contained mollusks duplicating the species reported by Leonard as occurring below the ash. It appears that the mollusks reported by Frye, Swineford, and Leonard (1948) and Leonard (1950) from Locality no. 38, Beaver County, Oklahoma, as taken from below the Pearlette ash at the Gate pit, were specimens collected above the Pearlette ash.

We are grateful to Dr. Stuart L. Schoff who visited the area with us in the summer of 1951. He checked the location of the Gate ash pit and of the vertebrate finds in that area from aerial photographs. The Gate ash pit occurs in the NW ¼ sec. 8, T.5N., R.28 E.C.M. Hibbard (1944, p. 743) gave the locality of the Gate ash pit as being where the corners of sections 5, 6, and 8 join.

The exact age of the beaver and associated vertebrates reported is unknown.

Considerable deposition took place after the Pearlette ash was deposited. The immediate area west, north, and northeast of the ash pit has been involved in a large sink or a series of sinks. The deposits containing the new beaver and associated vertebrates occur well above the horizon of reworked ash in beds that were laid down in a large basin. The basin appears to have been a lake at certain stages of its development. Mengel (1952) reported the remains of a white pelican taken in the SW ¼, sec. 5, T.5N., R.28 E.C.M., approximately 220 yards due east of the locality where the beaver was collected. The pelican was taken at a slightly lower horizon than were the other vertebrates. The position of the deposits in which the beaver was found indicates that the beds are approximately the age of basin deposits in Meade County, Kansas, which are considered to belong to the base of the Kingsdown formation (Hibbard, 1949).

The beaver has been found to differ from any other known beaver, and represents a heretofore undescribed genus and species.

Paradipoides, gen. nov.

Genotype.—Paradipoides stovalli sp. nov.

Diagnosis.—A beaver as large as *Castor canadensis michiganensis* Bailey. M_1 and M_2 with S-pattern typical of *Dipoides* in adult pattern. Alveolus of lower incisor much like that of *Castor* in that it does not rise posteriorly above the level of crowns of molars, nor does it project laterad behind the molars to form a prominent bulge on the external face of the mandible. Coronoid fossa shallow as in *Castor* rather than deep as in *Dipoides*.

Paradipoides stovalli sp. nov.

Holotype.—No. 27286, U.M.M.P., distal part of right ramus, bearing M_1–M_2, the alveoli of M_3, and the incisor (Fig. 1). Collected July 24, 1950, by Thomas M. Oelrich.

Horizon and type locality.—Middle Pleistocene, post-Pearlette ash in age. Southeast corner of sec. 6, T.5N., R.28 E.C.M., Beaver County, Oklahoma.

Description of holotype.—The mandible is that of a young adult. M_1 and M_2 each possesses a parastriid, mesostriid, hypostriid, and an anterior fossettid. The mesostriid and hypostriid extend to the base of each tooth and are filled with cement. The bases of the teeth are completely open. The parastriid of M_1 extends 2.6 mm. below the occlusal surface. The anterior fossettid of M_1 is small, compressed anteroposteriorly, and probably would be lost with very little additional wear.

A section of M_1, made 8.5 mm. below the present triturating surface, shows the typical S-pattern of *Dipoides* with no indication of the paraflexid (Fig. 1c).

The parastriid of M_2 extends 2.4 mm. below the occlusal surface and the paraflexid is strongly developed, although it does not extend as far across the tooth as does that of M_1. The anterior fossettid is more nearly round than that of M_1, but is not as large. Section of this tooth at a level of 9.5 mm. below the occlusal surface shows a simple S-pattern which is more compressed anteroposteriorly than in M_1.

The size of the alveolus of M_3 indicates that this tooth would be approximately the same in the transverse dimension as M_2.

The alveolus of the incisor, at the level of the posterior border of M_2, is nearly round, with a slight flattening superiorly. There are no ridges in the alveolus which would indicate that the incisor was grooved. It may be significant that the alveolus of the incisor of *Castoroides* shows definite bony ridges at this level, corresponding to the grooves in the enamel face of the incisor. The incisor alveolus ends behind the alveolus of M_3 at a distance approximately equal to the antero-posterior diameter of M_2, and in line with the labial side of the tooth row at a level below the plane of the occlusal surfaces of the teeth.

Measurements in millimeters of holotype, No. 27286 U.M.M.P.

M_1, Anteroposterior diameter, occlusal surface	7.3
M_1, Greatest width of occlusal surface	4.7
M_1, Anteroposterior diameter, 8.5 mm. below occlusal surface	8.3
M_1, Greatest width, 8.5 mm. below occlusal surface	8.0
M_2, Anteroposterior diameter, occlusal surface	7.8
M_2, Greatest width of occlusal surface	4.4
M_2, Anteroposterior diameter, 9.5 mm. below occlusal surface	8.1
M_2, Greatest width, 9.5 mm. below occlusal surface	8.4
Transverse diameter of incisor alveolus, level of M_2	8.9
Vertical diameter of incisor alveolus, level of M_2	7.3

This species is named for J. Willis Stovall, who has devoted many years to the study of vertebrate fossils.

Comparison.—The mandible of *Paradipoides stovalli* presents a curious mixture of characters, some of which correspond rather closely to *Dipoides* and some to *Castor*.

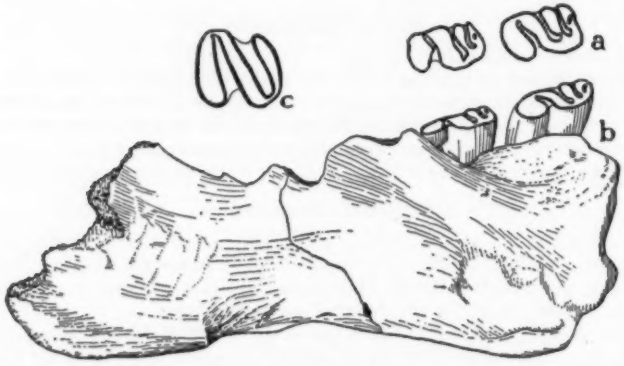


FIG. 1.—(a and b) Occlusal view of RM_1-M_2 and lateral view of right ramus; (c) crown view of M_1, taken 8.5 mm. below occlusal surface, of *Paradipoides stovalli* gen. et sp. nov. Holotype U.M.M.P. no. 27286. All × 1½. Drawings by Jane S. Mengel.

Except for the rather considerable difference in size, there are no characters of M_1 and M_2 which will distinguish them from those of known species of *Dipoides*. The shape of the incisor as indicated by the alveolus is likewise similar to that of *Dipoides*. On the other hand, the conformation of the mandible is distinctly more like that of *Castor* than like that of *Dipoides*. As stated above, the incisor alveolus of *Paradipoides stovalli* ends directly posterior to and below the level of the crown of M_1, in line with the labial side of the molar series. There is no alveolar tubercle on the lateral aspect of the jaw, as in *Castor*. The coronoid fossa is shallower and smaller than in *Castor*.

In *Dipoides wilsoni* Hibbard, as well as in *Castoroides ohioensis* Foster, however, the root of the incisor projects much farther posterolaterad, a distance approximately equal to the length of the molar tooth row, and ends above the level of M_3 (cf. Wilson, 1934: 22). The alveolar tubercle is on a line which makes an approximately 45° angle with that of the molar tooth row at the posterior border of M_3. There is, in these forms, a prominent alveolar tubercle and a very deep coronoid fossa.

The depression between the alveoli and coronoid in *Paradipoides* is less than in *Castor* of similar size. In contrast, this pit in *Dipoides* is relatively broader and deeper than in *Castor*.

The angular process of the mandible of *Paradipoides stovalli* approaches in character that of *Dipoides* and *Castoroides*. It is relatively much stronger than that of *Castor*, and has a broad, thin shelf extending horizontally inward from the inferior border of the process. This inflection of the border of the angular process is characteristic of *Dipoides* and *Castoroides*.

Associated vertebrates.—Two left preopercula, No. 29008, of *Perca* cf. *flavescens* (Mitchill), tooth fragments of the giant beaver, and a metacarpal, No. 29010, of a canid the size of a coyote, were taken at the same horizon as *Paradipoides*. Pieces of the carapaces of pond and river turtles and two fragmentary bird bones were found on the slope of the outcrop. Part of a tibia and femur, No. 29009, of the giant beaver (*Castoroides* sp.) along with numerous sections of the molar teeth of a large mammoth (*Mammuthus* cf. *columbi* Falconer) and fragments of the molar teeth and a metacarpal, No. 29152, of *Equus* sp. were taken from the fine sand horizon just below the silt deposit which contained *Paradipoides*.

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[This paper was subsidized by an anonymous donor]

University of Michigan, Department of Anatomy and Museum of Paleontology, Ann Arbor, Mich. *Received October 11, 1951.*

GENERAL NOTES

THE FACIAL GLANDS OF A FRUIT-EATING BAT, *ARTIBEUS JAMAICENSIS* LEACH

This is the second in a series of investigations pertaining to the facial glands of bats. In the first (Werner, Dalquest, and Roberts, Jour. Mamm., 31: 395–399, 1950), Work was confined to an insectivorous species, *Tadarida cynocephala* LeConte, a member of the family Molossidae. The following findings are presented on the types of glands found in the face of *Artibeus jamaicensis* Leach, a member of the family Phyllostomatidae. This species is of large size and feeds entirely on fruit, insofar as is known. It has a wide geographic range, occurring in the tropics of North and South America and the islands of the West Indies.

Materials and methods.—Specimens of *Artibeus jamaicensis* were collected in the state of San Luis Potosí, Mexico, in the fall of 1950. Entire animals were fixed in a solution of ten per cent formaldehyde for 24 hours before being stored in seventy per cent ethyl alcohol. Tissues were subsequently dehydrated in increased concentrations of ethyl alcohol. Toluene was substituted for the cedar wood oil used as a clearing agent in the earlier study. Increased ease in cutting the tissues justified this change. Tissues were stained with Harris' hematoxylin with the alcoholic eosin counter stain, and Lillie's variant of iron hematoxylin and metachromatic dye (Lillie, R. D., Histopathologic Technic, p. 149, Blakiston Co., 1947).

Dr. Lillie, in his discussion of the preparation of Weigert's iron hematoxylin, comments on the relative instability of the solution and suggests ". . . if large numbers of sections are being stained, it may have to be made fresh twice weekly." Work in the laboratory here indicated that if many more than a hundred slides are immersed in the same solution, its effectiveness disappears.

Discussion.—Two types of facial glands were identified in *Artibeus jamaicensis*. Sebaceous glands, similar to those of *Tadarida cynocephala*, were found scattered profusely in the membrane of both the upper and lower lips. These are typical holocrine glands. They are associated singly or in pairs with small hair follicles, and in clusters with large bristles. In our report of *Tadarida cynocephala* the relationship between such glands and bristles was discussed. Professor W. A. Wimsatt of Cornell, in a personal communication, graciously pointed out that the lower right hand figure on page 397 could be referred to as a "sinus hair," and that as such the enveloping follicle is fibrous rather than muscular. Reexamination of our slides bears this out. The prominent nose leaf of *Artibeus jamaicensis* was also examined, and clusters of sebaceous glands were the only glands found there.

Salivary glands, consisting of three to four groups of cells, were found on the extreme lateral borders of the lower lips of *Artibeus*. In contrast to the serous type of salivary glands found in the face of *Tadarida cynocephala*, the glands of *Artibeus* invariably reacted positively to the metachromatic dye technique, indicating the presence of mucin. Had the metachromatic dye technique not been used, one might still, with a reasonable degree of security, have identified these glands as belonging to the mucous variety. The microscopic picture (Pl. I) corresponds exactly to the classical description of cells in such glands. The cells are irregularly cuboidal in shape. The cytoplasm, with ordinary stain technique, is relatively clear, with small amounts of basophilic materials. The highly chromatic nuclei of the pre-secretory cells are displaced contiguous to the bases of the cells, compressed, with their long axes lying parallel to the bases of the cells.

These salivary glands are imbedded deeply in the epithelium of the lower lip, and surrounded by a capsule of connective tissue. Trabeculae extend in from the capsule, dividing the gland into lobes and lobules.

The question immediately presents itself—why the necessity of mucous salivary glands, the secretion of which would increase the viscosity of the saliva, in a form of bat whose diet consists entirely of fruit? What may be a partial answer is suggested by the feeding habits of the species. The fruit eaten is held between the thumbs of the bat, and pieces are

bitten from the fruit as the bat hangs suspended by its feet. The pulp is separated from the rind in the mouth of the bat; the rind is molded into small, flattened, oval pellets, which are subsequently ejected. These pellets are held together by the mucus secreted by the salivary glands.

Summary.—Two types of glands are present in the face of *Artibeus jamaicensis:* sebaceous holocrine glands are present in the upper and lower lips, as well as in the nose leaf, and three or four salivary glands are present in each extreme ventral angle of the lower jaw. The salivary glands, on the basis of their positive reaction to the metachromatic dye technique and their characteristic histological picture, are identified as true mucous glands.—W. W. Dalquest, H. J. Werner, and J. H. Roberts, *Department of Zoology, Louisiana State University, Baton Rouge, Louisiana.* *Received March 5, 1951.*

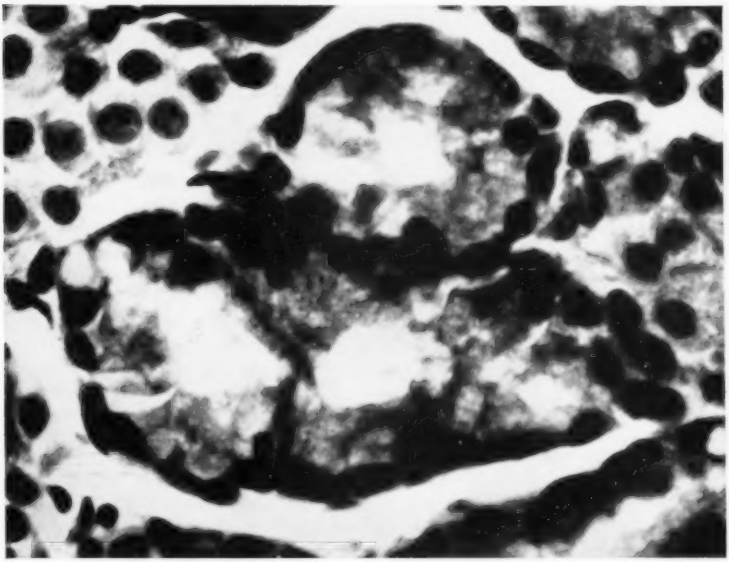

PLATE I

Section stained metachromatically. Basally situated nuclei of the mucous acini evident. The cytoplasm, shown here in relatively vivid relief, with an ordinary H. and E. technique stains at best, poorly, and is represented only as a wide meshed network. × about 500.

A MID-VENTRAL DERMAL GLAND IN *PEROMYSCUS MANICULATUS*

In the summer of 1949 the junior author first noticed a large mid-ventral gland on a male *Peromyscus maniculatus bairdi*. We then undertook to determine the structure of the gland and to learn whether or not it was present in all specimens of *bairdi* and in other forms of *Peromyscus*.

Ordinarily the gland is destroyed by the incision made along the mid-ventral line preparatory to skinning the specimen so it was not practical to examine all of the *Peromyscus* taken. However, examination of several specimens of each form available in Pennsylvania disclosed that this gland is present in both *P. m. bairdi* and *P. m. nubiterrae*, but is not present in *P. leucopus novaboracensis*. Additional comparative material was made available to us by Dr. Lee R. Dice, of the Institute of Human Biology, University of Michigan, and

one mature specimen of each sex of the following forms was examined: *P. polionotus leucocephalus, P. m. blandus, P. m. gracilis, P. m. bairdi.*

In all, six forms of *Peromyscus* were examined, four subspecies of *maniculatus* and one form each of *leucopus* and *polionotus*. Of these, the four subspecies of *maniculatus* all have the gland well developed in the males. No evidence of the gland was seen in either sex of the two other species examined.

As seen on the flesh side of the skin, there is no appreciable difference in the appearance of the gland in the subspecies of *maniculatus* examined. In each, the gland is apparent as a light-colored, thickened strip on the mid-ventral line, 20–23 mm. long, 2–3 mm. wide, and approximately 1 mm. thick.

Externally, the gland is most noticeable in mature male *bairdi* where it appears as a raised welt devoid of hair. The position of the gland is usually marked by a greasy discoloration of the fur along the mid-ventral line. In the one specimen of *blandus* examined, the glandular area was devoid of hair, but the gland itself was less noticeable. In both *nubiterrae* and *gracilis* the glandular area is thinly furred and the gland is not visible externally.

The mid-ventral gland is present in both sexes of *bairdi* although in the female it is reduced to approximately one-half as long and one-half as wide as it is in the male In the other forms of *maniculatus* examined, the gland was not present in the females.

Transverse sections through a gland from a mature male *bairdi* show that this structure consists of a group of enlarged sebaceous glands associated with hair follicles that are modified so that no hair is formed in them, and the follicular papillae are lacking. These glands seem to be similar, in all respects, to the dermal glands of *Neotoma* described by Howell (*Anatomy of the Wood Rat*, 1926).—Neil D. Richmond and Harry R. Roslund, *Pennsylvania Game Commission. Pittman-Robertson Project 37-R.* *Received March 3, 1951.*

CECAL VILLI IN A PIKA (*OCHOTONA PRINCEPS*)

The presence of villi on the so-called spiral valve in the cecum of a species of *Ochotona* (*Lagomys*) has been noted and figured by Tullberg (Nova Acta Soc. Sci. Upsal., Ser. III, 18: 1–514,1899). Cecal villi were described recently in the red tree mouse, *Phenacomys longicaudus* (Voge and Bern, Anat. Rec., 104: 477–486, 1949). In view of the infrequent occurrence of villi in the large intestine of mammals, we undertook to examine the cecal villi of *Ochotona* in some detail and to compare them with those of *Phenacomys*.

We have studied preserved and sectioned material from several levels of the intestinal tract of six specimens of *Ochotona princeps*, generously supplied to us by Mr. J. Harold Severaid. For the cecum of this species, at least, the term "spiral valve" is misleading. Rather, the cecum contains a series of complete rings, the number of which varies in different individuals. Counts made on three specimens showed 39, 40, and 47 of these rings. From each ring project villi, usually 12 per ring; however, as many as 15 and as few as 7 have been found, the latter on the smaller rings located close to the vermiform appendix. With few exceptions, the villi are flattened structures, ellipsoidal in cross section, somewhat like the fingers of a rubber glove, but distinctly wider at the base than at the apex. Measurements of fixed material indicated an average length of about 3 mm., ranging from 1.5 to 7.1 mm. Villi 6–7 mm. long were found rarely and were confined to 5–6 rings in the *ampulla coli*. The longer villi were more slender, reaching the lower width limit of 0.45 mm., and never the upper width limit of 1.1 mm. The average villus width was 0.8 mm.

As previously noted, the villi in *Ochotona* differ grossly from those of *Phenacomys* in being shorter, wider, and flatter. Histologic study revealed further differences, as well as certain similarities. The villi in both forms are glandular, the glands in *Ochotona* histologically resembling those of *Phenacomys* in their acinar structure. More smooth muscle and less lymphoid tissue occurs in the *Ochotona* villi, and large blood vessels and a rich subepithelial capillary plexus are present. The tall columnar epithelium is like that of the colon, showing little evidence of a striated border such as is present on the epithelium of the ileal villi.

In view of the association of alkaline phosphatase enzyme activity and absorptive proc-

esses in the small intestine, the villi of *Ochotona* were studied in the same manner as those of *Phenacomys*. In both species, ileal villi show intense alkaline phosphatase activity, and the colon epithelium is inactive. In contrast to the picture observed in *Phenacomys*, the epithelium of the cecal villi in *Ochotona* is virtually negative for this enzyme activity, as is the remainder of the cecal epithelium. Thus, it is suggested that the villi in the cecum of *Ochotona* may not serve the same function as those in the small intestine or as those in the cecum of *Phenacomys*.

Two additional features of intestinal microanatomy in *Ochotona* were noted. Both the vermiform appendix and the "tubiform diverticulum" (Kostanecki, Bull. int. Acad. Cracovie, Ser. B., No. suppl., 1–295, 1926) located at the ileocecal junction are almost solidly lymphoid structures, as described by Crabb and Kelsall (Anat. Rec., 81 suppl: 64–65, 1941), with reduced lumina lined by tall columnar epithelium. Distinct stromal alkaline phosphatase activity is present subepithelially in the colon and the cecum, including the villi in the latter, differing from the situation in *Phenacomys*, wherein such activity is not seen.—Marietta Voge and Howard A. Bern, *Department of Zoology, University of California, Berkeley.* *Received April 6, 1951.*

NOTES ON THE LIPIDS IN SOME WILD MAMMALS

Relatively few published reports are available concerning tissue lipids in *wild* mammals (for recent ones see, Wilber and Musacchia, Jour. Mamm., 31: 162–167 and 304–309, 1950). A few specimens each of *Didelphis virginiana*, *Ondatra zibethica spatulata*, and *Rangifer arcticus* were obtained. Blood was removed from the ventricles and analyzed for lipids. The fresh bile from the opossum was also analyzed. Table 1 gives the average values for the various lipids. The two Alaskan mammals, the caribou and the muskrat, have more blood fatty acids than does the Missouri opossum. The phospholipid is lowest in the caribou.

Table 1.—*Average values for various lipids in fluids from different mammals. Values in mg. per 100 cc.*

TISSUE	FATTY ACIDS	CHOLESTEROL	PHOSPHOLIPID
Opossum blood	400	150	600
Opossum bile	171	635	142
Muskrat blood	600	110	400
Caribou blood	600	157	275
Caribou plasma	377	68	125

Blood cholesterol values show no great variations from the mammalian pattern. Of special interest is the large amount of cholesterol in the bile of the opossum. In man there is 13–76 mg. cholesterol per 100 cc. of bile depending on diet (Salomon, Arch. Verdauungs-Krankh., 39: 46, 1926); in the hippopotamus bile there is about 22 mg. per 100 cc. (Gardner, Biochem. Jour. 18: 777, 1924).—Charles G. Wilber, *St. Louis University, Biological Laboratories, St. Louis, Mo.* *Received April 20, 1951.*

NOTIOSOREX IN ARKANSAS

In the process of cataloguing the mammal collection of the University of Arkansas the writer recently came across a previously unreported shrew collected at Natural Dam, Crawford County, Arkansas, on February 4, 1935, by Mr. T. H. Holder. The evident distinctness of the specimen from any of the other small shrews common in the area prompted the writer to send it to Dr. H. H. T. Jackson of the U. S. National Museum who identified it as *Notiosorex crawfordi crawfordi* (Coues).

The localized distribution and rarity of this species are well known. Not only is this a new species record for Arkansas, but it considerably extends the known range of the species. Fisher (Jour. Mamm., 22: 263–269, 1941) has summarized the presently known distribution

of *Notiosorex crawfordi* with a listing of localities from which it has been taken. The present record extends the known range about 650 miles northeast of San Antonio, Texas, and about 380 miles in a northeasterly direction from the other nearest locality, Tula canyon, Briscoe County, Texas (Davis, Jour. Mamm., 22: 319–20, 1941). The writer has been advised by Dr. Jackson that another specimen of *Notiosorex* was collected quite recently in southeastern Oklahoma, which would indicate that northwestern Arkansas is on the eastern edge of its range and that the species' range extends over much of Texas and portions of Oklahoma. There also seems to be a strong possibility that this specimen may be part of a relic fauna, representing a formerly drier climate, which has managed to persist locally in scattered areas.

Measurements of the specimen taken from the dry skin are: Total length, 94 mm.; tail length, 26 mm.; hind foot, 10.3 mm.; ear from notch, 7 mm. Skull measurements are: length, 17.8 mm.; palatal length 6.7 mm.; cranial breadth, 8.4 mm.; cranial depth, 4.9 mm.; interorbital breadth, 4.2 mm.; maxillary breadth, 5.1 mm.; tooth row from front of second incisor, 6.2 mm.

The specimen is colored as follows: Dorsal surface dull plumbeous gray, tipped with brown; ventral surface lighter gray tipped with buff; tip of tail slightly pencilled. The incisors, unicuspids, and first molar are tipped with orange. The specimen (UAZM35-11) has been deposited in the Biological Surveys collection of the U. S. National Museum.—JOHN A. SEALANDER, JR., *Zoology Department, University of Arkansas, Fayetteville, Ark.* *Received April 23, 1951.*

SOREX PALUSTRIS AND *SOREX DISPAR* FROM THE GREAT SMOKY MOUNTAINS NATIONAL PARK

Two species of shrews have been recorded for the first time in the Southern Appalachian Mountains. These species are considered separately below.

Sorex palustris probably **S. palustris punctulatus** Hooper.—A male *Sorex palustris* was trapped on November 24, 1950, on the bank of the West Prong of the Little Pigeon River in the Great Smoky Mountains National Park, Sevier County, Tennessee. Eight additional specimens were collected from several localities in the same drainage on December 3, 1950, and in the period between December 17–21, 1950. All water shrews were taken from very similar habitats. Thus only a detailed description of the place where the first specimen was collected is given.

This general locality is at an elevation of 3700 feet along the cross-mountain highway (Tenn. 71) between Gatlinburg, Tennessee, and Newfound Gap in the Great Smoky Mountains National Park. At this place the highway is parallel and within 50 feet of the West Prong. As a result of road construction, many large rocks extend in a loose jumble from the edge of the road down to the water and form the north bank of the stream which, at this point, is 20 to 30 feet wide. Very little plant life grows among the rocks, but the general vegetation of the stream margin in this vicinity is a dominant growth of hemlock (*Tsuga canadensis*), red spruce (*Picea rubens*), and yellow birch (*Betula lutea*). Rhododendron (*Rhododendron maximum*) grows abundantly as a streamside understory. On November 23, nine mouse traps were set in this area. They were placed at intervals of about ten feet at the water's edge beneath overhanging rocks or in crevices. They were baited with a mixture of peanut butter, bacon grease, and rolled oats. The following morning a male water shrew was removed from one of the traps.

Approximately 300 trap-nights were set for water shrews in the trapping done on December 2 and December 17–21. About 240 of the trap-nights were along the West Prong and its tributaries at elevations of 3700 to 4700 feet. Eight specimens were obtained in this area. No specimens were obtained from 60 trap-nights along the Oconalufty River below Highway 107 at an elevation of 3700 feet, in Swain County, North Carolina. However, this does not necessarily indicate the absence of the water shrew along this stream. *S. palustris* is apparently not uncommon at least in some areas in the Great Smokies, yet its presence was not indicated by Komarek and Komarek (Bull. Chicago Acad. of Sci., 5: 137–161, 1938) who collected in this region during several years. Careful habitat selection and the placing

of traps under the concealment of overhanging banks or in rock crevices seems essential to success in collecting for this species. These factors have been discussed elsewhere in regard to the water shrew in Montana (Conaway, Amer. Mid. Nat. In Press), and they probably also apply in the Great Smoky Mountains.

The occurrence of the water shrew in Sevier County, Tennessee, establishes a new state record and represents a considerable southward extension of the range of this species. *S. palustris* has not previously been reported south of West Virginia where it is known from Preston and Randolph counties (Hooper, Occ. Papers Mus. Zool. Univ. Mich. No. 463, 1942) and Pocahontas County (Brooks, Audubon Magazine, July–Aug., 1945). At the present time it cannot be said whether or not the water shrew occurs as an isolated population in the Great Smoky Mountains. Careful collecting along the cool streams draining the higher mountains of Virginia, Tennessee, and North Carolina may be expected to show that it has a wider distribution than presently suspected.

Three Great Smoky Mountain specimens of *S. palustris* were compared with *S. p. punctulatus* specimens from West Virginia by Dr. Emmet Hooper. Since the Great Smoky Mountain specimens are in full winter pelage, while those from West Virginia are in summer pelage, accurate comparisons are impossible. Dr. Hooper found several differences which, however, may be due to individual or seasonal variations and he believes that until comparable pelages are available the status of the Smoky Mountain specimens should remain in doubt.

The nine specimens taken from the Great Smokies are all young of the year (as indicated by tooth wear). The reproductive tracts of the three males and six females are typical immature tracts similar to early autumn specimens of *S. p. navigator* from Montana. However, the testes of *S. p. navigator* undergo rapid growth and development early in December and specimens taken December 5 and 6 have been found to show considerable testicular enlargement and many mitoses in the seminiferous tubules (Conaway, *op. cit.*). The testes of males taken from the Great Smoky Mountains on November 24 and December 3 and 19 show no enlargement and the seminiferous tubules are solid, containing only Sertoli cells and spermatogonia. The epididymal epithelium is also undeveloped. Spermatogenesis probably occurs considerably later in the water shrews of the Southern Appalachians than in those from Montana. The averages of the standard measurements followed by the extremes in parentheses are as follows: Weight 10.3 gm. (9.7–10.8); total length, 141.4 mm. (136–148); tail, 60.3 mm. (58–64), hind foot 18.1 mm. (18–18.5). The stomachs of all specimens contained only insect remains. Fragments of immature forms of Plecoptera, Ephemerida, or Trichoptera were recognizable in five of the nine stomachs.

Sorex dispar Batchelder.—Up to the present time seven specimens of *Sorex dispar* have been collected in the Great Smoky Mountains National Park. In the summer of 1950 it was noted that specimen number 31 in the Great Smoky Mountains National Park's mammal collection, which was labeled *S. fumeus*, is in reality *S. dispar*. This specimen bears the following information: female, collected October 2, 1932, by R. V. Komarek on Clingmans Dome (elevation 6642 feet), Swain County, North Carolina; total length, 129 mm.; tail, 66 mm.; hind foot, 15 mm.

An effort was made to secure additional specimens of *S. dispar* by setting traps in talus as suggested by Richmond and Grimm (Ecology, 31: 279–282, 1950). On November 24, 1950, a specimen was trapped in the rocks between Highway 71 and the West Prong within 30 feet of the site where the first *S. palustris* was taken. On December 3, 1950, a second specimen was taken from this same area five feet above the water of the West Prong in a crevice between large rocks. The same day another specimen was trapped in a similar habitat at an elevation of 4700 feet between Highway 71 and Walker Prong. Still another *S. dispar* was trapped in a loose stone wall along the Walker Prong at an elevation of 4400 feet on December 19, 1950. All of the above-mentioned areas are in Sevier County, Tennessee. With the exception of the stone wall these habitats are artificial talus slopes resulting from road cuts. Vegetation on the talus is confined to moss and lichens with occasional shrubs. Two *S. dispar* were obtained, from a natural wooded talus slope just above Highway 107 at an elevation of 4400 feet in Swain County, North Carolina, on December 19, 1950. Scattered

buckeyes (*Aesculus octandra*) occur on this talus and moss and lichens are abundant on the rocks.

All specimens of *S. dispar* which we collected were taken in traps placed as deep in the rock crevices as possible. It appears that *S. dispar*, like *S. palustris*, is not uncommon in its restricted habitat in the Great Smoky Mountains. Approximately 190 trap nights were set for *S. dispar* and six specimens were obtained. The bait used was the same as that used in trapping *S. palustris*.

The present collections of *S. dispar* from Tennessee and North Carolina extend the known range of the species almost 200 miles southward in the Appalachians. The southernmost occurrence previously recorded is the single West Virginia specimen taken by A. H. Howell in Raleigh County in 1909 (Kellogg, Proc. U. S. Nat. Museum, 84: 446, 1937).

Of the six *S. dispar* collected by the authors, three are males and three females. All are young of the year (as determined by tooth wear) and the reproductive tracts are inactive. The average and extremes of the standard measurements are as follows: Weight, 4.7 gm. (3.8–5.4); total length, 130.2 mm. (128–132); tail, 63.5 mm. (62–66); hind foot, 15.2 (15–16). Richmond and Grimm (*op. cit.*) found that the stomach and intestines of three *S. dispar* which they analyzed contained chiefly centipede remains with some insect and spider fragments. The stomachs and intestines of the six specimens we examined all contained chiefly insect material. Coleoptera remains were identified in five tracts and Arachnida in two.

All specimens of both *S. palustris* and *S. dispar* are in the Great Smoky Mountains National Park's mammal collection, Gatlinburg, Tennessee.

The junior author served as Ranger-naturalist in the Great Smoky Mountains National Park in 1950. We wish to acknowledge the encouragement given us by Park Naturalist Arthur Stupka, who participated in our trapping operations.—CLINTON H. CONAWAY AND DONALD W. PFITZER, *Department of Zoology and Entomology, The University of Tennessee, Knoxville, Tennessee; and Tennessee State Game and Fish Commission, University of Tennessee Farm, Knoxville, Tennessee.* *Received March 8, 1951.*

[Contribution No. 48, Dept. of Zoology and Entomology, Univ. of Tennessee.]

A FERAL COATIMUNDI IN NORTHWESTERN OKLAHOMA

The finding of a feral coatimundi, *Nasua narica*, living along the North Canadian River near Woodward, Oklahoma, 500 miles north of the limits of its natural range, seems worthy of recording. The animal was killed November 12, 1950, by a thirteen-year-old boy, J. W. Pearson, of Woodward, who had seen the animal on several occasions during the preceding three weeks. The eviscerated carcass, 5 pounds 4 ounces in weight, was recovered by the junior author on November 15, 1950. That it was a female, as reported by those who removed the viscera, is borne out by the small size. The fully-developed skull and well-worn dentition indicate its complete maturity.

The coati had evidently been a captive for Pearson relates that twice when he encountered the animal it came down from its den tree and ran toward him "making noises." On both occasions this was interpreted as ferocious behavior and the animal was repulsed by gunfire. On the second occasion the firing was accurate and the animal was killed. We interpret the behavior as indicating a previously fearless and pleasant association with man. Another youth who also encountered the coati observed similar behavior.

The first observation of the animal was made on approximately the 20th of October. During the greater part of the ensuing period the weather was warm and sunny, but minimum temperatures recorded for November 9–12 inclusive were 23, 12, 15, and 20 degrees F., respectively. Even during this time the animal was active and apparently unaffected by the cold. Observers said that it was very agile and scampered up and down trees in the vicinity holding its tail in the characteristic erect position.

A nest was constructed by this animal in the crotch of a cottonwood tree approximately 25 feet above the ground. Unfortunately a gale blew it down before it could be photographed. It consisted of a large mass of twigs and vines loosely woven together. The bulk of the nest was composed of cottonwood twigs but about 10 per cent was grapevine. Nearly

all twigs bore leaves and it could be seen that they had been green when the limbs were broken. From the fallen structure it appears that the outside measured 30 inches in diameter, the inside was 15 inches. It was roughly globular in shape and was roofed over. There was a hole in the top large enough to admit the animal. Hair, a few unidentified seed fragments, and some dried grapes were found in the nest. Within a radius of 15 feet of the tree were the remains of two bobwhite quail. No other signs of feeding were apparent.

The site of the nest tree was about 75 yards from the river bank in the usual flood-plain association of western cottonwood (*Populus sargentii*), willow (*Salix sp.*), tamarisk, (*Tamarix gallica*), and grape (*Vitis longii*). The tree itself was extensively festooned with the latter, which may have had some bearing on its selection for a nesting site.

From the above data it seems that the coatimundi can survive in certain situations in Oklahoma under temperature conditions much below optimum for this animal. The individual certainly had been at large for more than three weeks. Judging from the nest material it may have been much longer, for cottonwood leaves in this area usually turn yellow and fall off in late September or early October.

The skin and skull have been placed in the Oklahoma Agricultural and Mechanical College Museum of Zoology.—Bryan P. Glass and William R. Hanson. *Contribution No. 178, Zoology Department, Oklahoma A. & M. College. Received March 19, 1951.*

THE NORTHERN ELEPHANT SEAL ON SAN MIGUEL ISLAND, CALIFORNIA

For the past twenty years the elephant seal, *Mirounga angustirostris*, has been reported from San Miguel and San Nicolas Islands. In August, 1925, I saw a single female in a colony of Steller's sea lions on San Miguel Island. I searched for elephant seals on San Nicolas Island in 1945, but failed to find any.

While engaged in archeological work for the Santa Barbara Museum of Natural History in June of 1950, Mr. Phil C. Orr, Curator of Anthropology, reported seeing between 50 and 70 elephant seals on the west end of San Miguel Island. On receiving his report, arrangements were made to fly to the island to make some studies and motion pictures of the animals.

I went over on July 7, 1950, since no one was to be permitted on the island after July 9, after which it was to be used as a bombing range.

We flew over the west end and located the animals lying on the sand. The pilot said he would set the small plane down on a little dry lake bed, and then we would have to walk about two and one-half miles to where we saw the seals.

Although we planned to spend one day, due to the fog we spent only about two hours actually with the animals. About 125 feet of color film was made, and most of it is very good. In the film about 25 elephant seals can be seen on the shore. There were some in the water, but we made no attempt to take an actual count.

Through the efforts of Dr. Richard W. Bond of the United States Soil Conservation Service, the west end of San Miguel Island, where the elephant seals seem to stay, has been set aside as a sanctuary where no bombing will be permitted by the Air Force. It is hoped that in a few years these seals will again become established on the Channel Islands where they were so abundant one hundred years ago.

I was assisted in this work by Mr. Richard Finley of the Museum Staff.—Egmont Z. Rett, *Curator of Mammalogy, Santa Barbara Museum of Natural History, Santa Barbara, California. Received February 23, 1951.*

RECORDS OF THE FLYING SQUIRREL (*GLAUCOMYS VOLANS*) IN MÉXICO

Flying squirrels (*Glaucomys volans*) are much more widespread in occurrence in México than the latest revision of the species (N. Amer. Fauna, No. 44, 1918) indicates. In that systematic review Howell listed two specimens from Teopisca under the name *G. v. goldmani*. Teopisca is located at an elevation of about 6000 feet in central Chiapas. He also stated that flying squirrels were reported to occur at Pinal de Amoles in northeastern Querétaro. These apparently were the only records known to him of the occurrence of the species in México. Following are other records of the species in the Republic. Goldman (Jour.

Wash. Acad. Sci., 26: 463, 1936) mentions three specimens. One, the holotype of *G. v. herreranus*, is listed as taken in the mountains of Veracruz. The other two are reported to have been secured in the Sierra Madre of Chihuahua; they are the basis for the name *G. v. madrensis*. On 14 January 1949 Dr. H. O. Wagner trapped a flying squirrel in a forest of large oaks at an elevation of about 9500 feet on Cerro San Felipe, Oaxaca. That specimen is now contained in the University of Michigan Museum of Zoology. On 18 February 1949 Dr. George M. Sutton saw a flying squirrel glide from one pine tree to another in a pine-oak forest located 9 kilometers (by highway) south of Pátzcuaro, Michoacán. It was at dusk when he made the observation; he noticed a bat flying overhead shortly before he saw the squirrel. In early March, 1949, natives of Los Pescados, a village located at an elevation of about 10,000 feet on the north slope of the Cofre de Perote, Veracruz, reported that they occasionally saw small squirrels that came out at night and that glided from tree to tree. Their free description of the habits and appearance of the animals in question seemed to us to fit flying squirrels precisely. These several records indicate that the range of the species *Glaucomys volans* is much larger than previously has been suspected. It probably encompasses most of the high mountains of México.

Our specimen from Cerro San Felipe does not entirely agree with the holotype of *herreranus*, *goldmani*, or *madrensis*. It is paler and more buffy dorsally and has much less cinnamon on the posterior half of the underparts than does the type of *herreranus*. The upper parts of *herreranus* are cinnamon brown; those of the San Felipe specimen are tan. Compared with the holotype of *goldmani*, the San Felipe specimen is paler and less reddish dorsally and is a paler buff ventrally. The paratype of *goldmani* also is darker dorsally; it has a strong pinkish cinnamon wash on the chest, belly, and lower thighs that is not seen in the San Felipe specimen. The holotype of *madrensis* is badly worn and faded; the paratype also is faded. Apparently originally both were paler dorsally and ventrally than is the Oaxacan specimen. Whether our specimen represents a geographic race different from any of the three now ascribed to the Republic can not be determined until variation in the species in México is better understood. For convenience in filing in the Museum collections the specimen is identified as *G. v. goldmani*, the nominal form with which it agrees best.—Emmet T. Hooper, *University of Michigan Museum of Zoology, Ann Arbor. Received April 6, 1951.*

RED-TAILED HAWK A MOLE PREDATOR

W. B. Davis in a recent note (Jour. Mamm., 32: 114–115, 1951) lists the few known instances of natural predation on moles. His information indicates moles are preyed on sparingly by the barn owl, horned owl, coyote, red fox, grey fox, and cottonmouth snake.

To this list I would like to add the western red-tailed hawk (*Buteo jamaicensis calurus*). On May 4, 1947, about two miles north of Corvallis, Oregon, two Townsend moles (*Scapanus townsendi*) were found in the nest of a red-tailed hawk. Neither mole appeared damaged in any way, their skins being unbroken. On a later visit no sign of their carcasses could be found.—A. I. Roest, *Zoology Department, Oregon State College, Corvallis, Oregon. Received March 24, 1951.*

OBSERVATIONS ON THE HOARY BAT IN INDIANA AND ILLINOIS

In view of the paucity of breeding information on the hoary bat (*Lasiurus cinereus*), particularly in the midwestern states, it seems worthwhile to record the following observations.

During the spring and early fall months, 1946–1950, several wildlife students at Purdue University collected bats extensively in the vicinity of Lafayette, Indiana. An effort was made to secure unusual species and the hoary bat was especially sought. Not until the spring of 1948, however, was the first record of this comparatively rare bat obtained.

On May 19, 1948, a female containing two foetuses was shot by Richard G. Prasil in a field bordering the Purdue Dairy Woods. Two evenings later, on May 21, a second female, also with two foetuses, was collected at the same location. Several more of these bats were

taken at this site in the weeks that followed, until nine were deposited in the wildlife laboratory collection at Purdue. All were females and all contained twin foetuses (Table 1).

On May 31, a lactating female was collected in Vermilion County, Illinois, approximately 120 miles southwest of Lafayette, Indiana. Unfortunately, no young were found. Although probably six other hoary bats were observed, no attempt was made to procure them; notes were taken on time of appearance, manner of flight, etc. The following is a summary of the particulars noted:

The flight of the hoary bat was more direct and driving than that of smaller bats. The wing beat seemed to be more deliberate, regular, and bird-like, rather than butterfly-like as in most of the Vespertilionids. As pointed out by Merriam (1884) and others, these bats fly swiftly. But, in contrast to the irregularity cited by some authors as a distinguishing characteristic of this species, the flight of the hoary bats observed here seemed strikingly direct and purposeful.

The cruising range seemed to be larger than that of other bats associating with *cinereus*, particularly the big brown bat (*Eptesicus fuscus*) and the Indiana bat (*Myotis sodalis*). The following excerpt from notes taken by Russell E. Mumford at the time of these observations illustrates this point:

"Hoary bats were frequently observed to make forays in the form of a straight line, as if the bat were leaving that particular area for good. These forays often took the bat entirely out of my range of vision, but in a minute or so the same bat, presumably, would appear and again circle the identical spot from which it had begun its side flight."

Hoary bats usually made their appearance considerably later than red bats (*Lasiurus borealis*); the latter came out shortly after sundown. This was in accord with most literature references which state that these bats do not appear until the light becomes very dim. The following observation by Richard G. Prasil indicated that this was not always the case.

"Three hoary bats were seen flying within a small woodlot near Gundy Cemetery in Vermilion County, Illinois. The date of the observation was June 20, 1948, and the time was 6:30 P.M., CST. The sun was still shining brightly and the temperature was around 75 degrees Fahrenheit. The trees at this spot were about ten feet apart and the bats were flying from three to fifteen feet above the ground."

None of these bats were secured, but number 623 was taken at this same locality three weeks earlier. Dalquest (1943) points out that, "There are several records in the field notes on file at the Museum of Vertebrate Zoology [California], of migrating hoary bats appearing in the air early in the evening." He mentions five individuals taken on May 26, 1923, which were shot ". . . before the violet-green swallows had left the air." He suggests that this behavior is typical of migration activity in this species. As indicated by the weight of the foetuses, it is possible that the females observed in the midwest were not migrating, despite their early evening activity.

Merriam (*op. cit.*) says, ". . . the time at which bats appear depends solely upon the *degree* of darkness." In support of this statement he presents a table showing increasingly earlier appearances of hoary bats from June 30 to October 8. Of this species he says, "In warm evenings it was not to be seen at all, and I have never observed it when the temperature was above 15°C. (59°F.)."

In view of present information it is questionable whether light and/or temperature are primary factors in determining time of appearance in this species. It may be that relative humidity or saturation deficit plays an important role in this respect, though data at hand are inconclusive. It is noteworthy that at the season and locality where the present observations were made, evening temperature drops are accompanied by marked increases in relative humidity, which often reaches 100 per cent without raining. Table 1 summarizes conditions under which bats were collected in Indiana. The figures were taken from a thermographic chart and are correct to the minute.

All specimens collected were females. This parallels Poole's (1932) observations in Pennsylvania and, as he points out, ". . . is in accord with observations on the sexual segregation of other bats during the period of parturition." Dalquest (*op. cit.*) also noted a segregation

of the sexes in California where Joseph Grinnell collected five males on one occasion. Poole (*loc. cit.*) further remarks that, "Statements that the hoary bat is always solitary are not borne out by our experience, as two or more were frequently seen hunting together." The present data from Indiana and Illinois also illustrated the tendency of this species to be gregarious, at least at certain times. These combined observations from California, Pennsylvania, and the midwest seem to indicate that this gregariousness is not limited to migrating bats alone. Perhaps there is a differential behavior between sexes after migration.

TABLE 1.—*Summary of phenological data and measurements pertaining to hoary bats taken in Indiana*

NUMBER	DATE 1948	TIME P.M., C.S.T.	TEMP. DEGREES F.	REL. HUMIDITY	WGT. GRAMS	FOETUSES	
						Sex	Wgt. Grams
622	5-19	7:30	64	98	33.1	♀	1.9
						♀	1.8
616	5-21	7:40	60	74	36.5	♂	2.47
						♀	2.98
619	5-28	7:58	73	94	38.3	♂	1.64
						♀	1.52
617	5-29	7:45	47	82	34.0	♀	2.31
						♀	2.35
618	5-29	7:48	47	82	33.9	♂	3.32
						♀	3.54
624	6-1	8:00	66	98	33.7	♀	3.9
						♀	4.0
628	6-3	8:45	64	70	30.6	♂	3.1
						♂	3.1
625	6-8	8:00	69	82	32.0	♂	2.4
						♂	2.3

As far as could be ascertained, there is but one published record of the collection of a breeding hoary bat in Indiana. This was a female with two young taken at Bloomington, Indiana, on July 12, 1905 (McAtee, 1907). Other records for this general latitude in the Mississippi valley include one cited by Poole (*op. cit.*) from Lexington, Kentucky, another from Lawrence, Kansas (Hall, 1933), and a third from Pratt, Kansas (Sprague, 1939). In view of the sparsity of these records, the relatively large size of the foetuses recorded here may be significant. Hamilton (1943) states that the young weigh about 4.5 grams at birth. Poole (*op. cit.*), using the average ratio at birth of young to adult in *Eptesicus fuscus* and *Myotis lucifugus*, predicted the hoary bat should weigh about 4.75 grams at birth. On this basis he considered foetuses weighing 2.5 grams to be within two weeks of birth. Assuming an increase of about one gram per week, at least one of the recent specimens from Indiana was within three to five days of parturition.

Seton (1909) states that four is the usual number of young at birth and that ". . . they are born, apparently, in the last week of May." Most of the recent records in the literature, together with the data presented here, indicate that two is the usual number and that par-

turition occurs most often in June, with some young being born in late May and early July. A study of published records reveals no apparent predominance in either sex at birth.

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ERNEST E. PROVOST AND CHARLES M. KIRKPATRICK, *Dept. of Zoology, State College of Washington, Pullman, and Purdue Univ., Lafayette, Indiana.* *Received April 18, 1951.*

HOARY BAT IN A SQUIRREL'S NEST

On a rather chilly day in November, Mr. I. G. Rucker, Jr., and I were walking along a wooded hillside near Augusta, Richmond County, Georgia. Out of curiosity we investigated the nest of a southern gray squirrel, built about 12 feet off the ground in the fork of a sapling. As we shook the sapling, we were surprised to hear a loud buzzing sound, something like the shrilling of a cicada, coming from the nest. Examination revealed a fine, large hoary bat (*Lasiurus cinereus*) ensconced within. It was apparently numbed by the cold, and could only buzz loudly and show its teeth.—WILFRED T. NEILL, *Research Division, Ross Allen's Reptile Institute, Silver Springs, Florida.* *Received April 9, 1951.*

NOTES ON THE ABUNDANCE OF THE EVERGLADES MINK

In 1948 Hamilton described the Everglades mink (*Mustela vison evergladensis*) on the basis of a single mutilated specimen from Collier County, Florida (Proc. Biol. Soc. Washington, 61: 139–140). The collector of the type specimen stated that he had spent a lifetime in the Everglades as a professional collector and had seen no more than five mink, all of these within a few miles of the type locality. Hamilton was unable to locate further specimens after "diligent inquiry," and concluded that the form was relatively rare. Such, however, is not the case.

In 1930, Roy Nash, then Special U. S. Commissioner to Negotiate with Indians, made an extensive survey of the Seminole Indians in the Everglades and the adjoining Big Cypress Swamp. He found that the Seminoles were trapping mink in the Everglades, and stated, "Mink in the extreme south (of Florida) are fairly common . . ." (71st Cong., 3rd Sess.; Senate Doc. 314, 1931).

In 1935 and 1936, the Reptile Institute bought various animal hides from certain local residents in the vicinity of Okeechobee, Okeechobee County, Florida. Mink hides were not among those wanted, but nevertheless over 100 were brought in during this period. The animals had been trapped in and about Lake Okeechobee, mostly in the vicinity of the town of Okeechobee. The hides were all small, the pelage dark and silky. No doubt the animals were *M. v. evergladensis*. At that time a fur company was located on Lake Okeechobee, and it, too, received many locally trapped mink hides—probably far more than

ever reached the Reptile Institute. Bailey (Bailey Mus. and Library Nat. Hist. Bull., 5, 1930) listed several localities in Florida for mink, all south of the type locality of *M. v. evergladensis*.

It may be mentioned in passing that the type locality of *M. v. evergladensis* does not lie in the Everglades, as was stated, unless one subscribes to the popular and wholly inaccurate designation of all South Florida as "Everglades." It lies, instead, in the Big Cypress Swamp about 40 miles west of the Everglades proper. The distinction between Big Cypress and the Glades is more than a pedantic one, for the two are very different ecologically. The first is a vast expanse of pond cypress with scattered areas of pine flatwoods, while the second is essentially an extensive saw-grass marsh.—E. Ross Allen and Wilfred T. Neill, *Research Division, Ross Allen's Reptile Institute, Silver Springs, Florida. Received April 9, 1951.*

CARNIVOROUS BEHAVIOR IN THE MUSKRAT

During the course of a field trip on the Cannon River, one mile north of Northfield, Minnesota, several muskrats (*Ondatra zibethica*) were observed eating fish (undoubtedly yellow perch, but these were not identified) at 2:20 P.M. on December 31, 1950. In view of the fact that the muskrat has been considered chiefly a vegetarian the following observations are offered.

Our attention was drawn to several muskrats diving into the shallow, running water of about 12-inch depth. We stopped so as not to disturb any others, and were able to observe (with 7 × 35 binoculars) the first muskrat at a distance of twenty feet sitting on a fringe of ice next to the water's edge holding a frozen fish with its front feet and eating it much in the manner of eating corn from a cob. A very short time later, those that had apparently been frightened by our approach reappeared and crawled onto the fringe of ice on the opposite bank of the river, a distance of about 100 feet from us. While we were still watching the first muskrat eating its fish, another muskrat emerged from the rapids and joined those on the opposite bank of the river. He squatted on his hind legs holding a fish with his front feet and proceeded to eat it in the manner already described. We were able to watch the first muskrat for about five minutes. On trying to photograph him he was frightened into the water. The one on the opposite bank was observed for another five minutes. None of the other five muskrats in the same area at the time were seen to be eating in this manner, but were actively diving into the water as though hunting for food. Since that date this area of the river has frozen over so further observations have been impossible.—Orwin A. Rustad, *Department of Biology, St. Olaf College, Northfield, Minnesota. Received March 12, 1951.*

SOME OBSERVATIONS ON THE RED HOWLING MONKEY (*ALOUATTA SENICULUS*) IN VENEZUELA

During a zoological expedition to the Venezuelan llanos and the Orinoco River, organized by the Department, of Biology, University of Caracas, I had the opportunity to make some observations on the red howling monkeys.

While stationed for some days at Parmana, a village on the left bank of the Orinoco in the State of Guárico, I made, on April 4, 1950, in the company of another colleague, a short excursion to the gallery forest which borders the river. Some two kilometers eastward from the village we met a small troop of these monkeys, perched on the upper branches of a large tree, quite silent and motionless. They allowed us to approach them closely enough to see that the troop was composed of four adult and three young individuals. Only when we were under the tree did they start moving slowly along the branches in the direction of an adjoining tree. In thus moving the animals uttered low, muttering sounds, something like guttural "oo-oo-oo-oo" syllables pronounced at a medium speed. As soon as we stopped they stopped too, and after a while, to our surprise, began to return to the branches immediately above our heads. Some of them (the adults) were even bold enough to approach us along the lower branches at a distance of only four or five meters. Soon we began to realize

the purpose of such a maneuvering since, seated in the branches directly overhead, the monkeys suddenly started to urinate. As a result of this watery "attack" we were obliged to withdraw.

There are many instances in the literature where the question of urination and defecation by the howling monkeys as a means of defense is dealt with. Some authors entirely deny the possibility of such a behavior being employed for that particular purpose, some again state that it is to be observed on rare occasions, only being unconscious and produced by fear. My observations speak exactly to the contrary, namely, that the howling monkeys urinate quite consciously and in order to drive away "unwanted guests." It would be difficult to attribute said urination to fear since we did not persecute the animals and they even turned back to attack us and did not show any signs of fear whatsoever.

For the purpose of completing our scientific collection I shot down one of the adult males. The crash of the shotgun did not bother the animals particularly, they just moved over to the adjoining tree where they remained crouching and almost motionless while we proceeded to skin the killed specimen on the spot, in a little clearing of the forest, and which took us about two hours.

A section of the stomach of the killed animal was full of vegetable food which was almost undigested, and was spreading a peculiar aromatic scent. This scent and other characteristics indicated that the food consisted chiefly of a Venezuelan ragweed (*Ambrosia cumanensis*) which grows in large quantities on the sandy banks of the Orinoco. Since the time when we first met the monkeys was about 9 A.M., and the food showed only slight marks of digestion, it can be assumed that it had been eaten in the morning of the same day, most probably at sunrise (from 5 to 6 A.M.). From where we found the monkeys to the brim of the water, the distance covered with forest measured only about 300 meters, followed by a sandy strip 50 to 70 meters broad which separated the forest from the site where said ragweed grew, the latter forming the last zone of vegetation at the brim of the water. This sandy slope, except for some little bushes, was almost barren, so that the monkeys had to cross it on ground and without any shelter. This circumstance contradicts those observations which speak of the howling monkeys as leaving the trees in exceptional cases only and for a very short time, namely, as long as is needed to quench their thirst.

Since the contents of the stomach consisted almost exclusively of ragweed (I found some roundish seeds of the size of orange seeds as well, but I could not identify them), it is to be supposed that this ragweed is one of the main food items of the howling monkeys during the dry period.

I had the opportunity to observe the rest of the troop several times during the next two days (and once at night, at about 1 A.M.) while I was still in the vicinity. They could always be seen in the same tree where I had observed them for the first time.—J. RACENIS, *Departamento de Biología, Universidad Central de Venezuela, Caracas. Received March 5, 1951.*

THE STATUS OF *NYCTICEBUS COUCANG BRACHYCEPHALUS* SODY

Mr. H. J. V. Sody has recently proposed the subspecific name *Nycticebus coucang brachycephalus* for a specimen, not seen by him, of slow loris from Pulo Tebing Tinggi, Sumatra (Treubia, vol. 20, pt. 2, p. 145; October, 1949). His knowledge of the animal is based entirely on the brief account and measurements of it published by Lyon (Proc. U. S. Nat. Mus., vol. 34, p. 669, 1908) under the name *Nycticebus malaianus*.

The specimen in question is No. 144328 in the collection of the United States National Museum. It consists of the skin and skull of a young adult female obtained by W. L. Abbott, original number 4989, January 15, 1907, at Pulo Tebing Tinggi (also known as Pulo Rantau), one of several low islands lying close to the east coast of Sumatra and bordering the Strait of Malacca (approximate lat. 0° 50′ N., long. 102° 40′ E.). The skin is well made and in good condition except that the pelage on the lower back and about the base of the tail is worn. The skull is complete and unbroken, but the following teeth of the upper jaw are missing: both right incisors, both fourth premolars, and all the molars except the right M^1. The mandibles have been separated and glued together again in an abnormal position.

Concerning this specimen, Lyon remarked, "The bone has an unnatural appearance similar to that seen in skulls of animals kept in zoological parks. It may have been a captive specimen or lived amid otherwise unfavorable conditions." A statement in Abbott's field notebook corroborates this conjecture: "Bought from a Chinaman, origin uncertain. In captivity a long time." Lyon failed to mention a striking abnormality of the skull that apparently resulted from injury or disease; the flange-like anterior extension of the orbital ring is incomplete on the right side where it borders the frontal bone, thus giving the right orbit an irregular and abnormally large appearance and placing its dorsal margin about two millimeters posterior to that of the normal left orbit.

Sody justified naming this specimen as follows: "It seems necessary to form a new subspecies for this animal. The toothrow is rather small (19.4 mm.), but the special distinguishing character lies in the skull index, which is 77.8%, a relative breadth which has not yet been recorded in any other specimen of the whole species." The cranial measurements published by Lyon and copied by Sody are: Greatest length of skull, 54.5 mm.; basal length, 46.4; greatest width, 42.4; width of braincase above zygomata, 30; maxillary tooth row, 19.4; mandible, condyle to front of symphysis, 36. In checking these against the skull, I find that the measurements are essentially correct except for that of greatest width; here Lyon clearly erred, because the greatest width of the skull, instead of being 42.4 mm. as he stated, is actually 37.3 mm. When corrected on this basis, Sody's skull index (the greatest width expressed as a percentage of the greatest length) should be 68.4 per cent rather than 77.8 per cent. This is within the range of variation of most of the series of specimens representing various races for which measurements were tabulated (Sody, *loc. cit.*, p. 144).

Although the chief character originally assigned to the race is thus shown to be invalid, and the type specimen is known to be abnormal and of dubious origin, the name *brachycephalus* cannot satisfactorily be synonymized under any of the neighboring races. As Sody suggests, the specimens from Batam Island, Rhio Archipelago, mentioned by Chasen (Bull. Raffles Mus., no. 10, pp. 8–9, 1936) seem to agree in general with the type specimen of *brachycephalus*. Until a comprehensive revision of the slow lorises is possible, *Nycticebus coucang brachycephalus* may be regarded as a race inhabiting the low islands bordering the southern end of the Strait of Malacca and having the following characters: Size small as in *borneanus* and *bancanus;* dorsal stripe indistinct and underparts dull as in *bancanus*, but lacking the bright orange wash on the upper parts of *bancanus*, *natunae*, and *borneanus;* throat, cheeks, sides of neck, and legs darker than in *coucang* and *hilleri;* temporal ridges of skull widely spaced and inconspicuous, thus resembling *bancanus*, *natunae*, and *borneanus* and differing from *coucang* and *hilleri;* lower outer rim of orbit broad as in most races, not narrow as in the type of *bancanus;* lateral upper incisors present as in most specimens of *coucang* and *hilleri*, in this respect differing from *bancanus*, *borneanus*, and *natunae*.—David H. Johnson, *U. S. National Museum, Washington, D. C.* *Received February 16, 1951.*

NOTE ON MISSING TEETH IN *MARTES AMERICANA*

While engaged in a study of age characteristics in skulls of *Martes americana* the author took occasion to note the occurrence of missing teeth in two extensive series available to him. One series of 107 skulls was obtained in 1939–40 from trappers in the Sawtooth Mountains of central Idaho. The second series of 97 skulls, collected from similar sources during the years 1940–41 and 1945–46 in western Montana, was loaned by Dr. Phillip Wright, Montana State University. The data were recorded according to methods described by Hall (Jour. Dental Res., 19: 103–143, 1940). Table 1 presents the data obtained.

It will be seen that in both series the first premolars were missing more frequently than any other teeth. Further, the incidence of such occurrences was much higher in the lower jaw. A smaller number of incisors was missing from the lower jaws. Hall reported similar results for the premolars, but did not note missing incisors. No cases of missing molars were noted.

In the Idaho series seventeen (16 per cent) of the skulls showed such abnormalities while in the Montana series 26 (27 per cent) such skulls were tallied. These percentages are

considerably higher than the 10 per cent incidence reported by Hall on the basis of 193 skulls.

In addition to actual failures to irrupt through the jawbone, both upper and lower first premolars were greatly reduced in size in eleven Idaho skulls while this condition was noted in seven additional lower jaws from Idaho.

Another variation, not discussed by Hall, but shown in his Plate I, Figure 9 (*loc. cit.*), is the crowding of the lower incisors so that usually both number 2 teeth are displaced posteriorly. Thus only three of the one hundred and seven Idaho and fourteen of the ninety-seven Montana specimens had the six incisors in a straight line between the two canines.

It is interesting that Coues (Fur bearing animals, U.S.G.S. Surv. of Terr., Misc. Publ. No. 8, 348 pp., 1877) described these conditions clearly though qualitatively.—WILLIAM H. MARSHALL, *University of Minnesota, St. Paul 1, Minnesota.* *Received April 14, 1951.*

TABLE 1.—*Number and location of missing incisors and premolars in 204 Martes americana skulls*

TYPE TOOTH	INCISORS						PREMOLARS					
	1		2		3		1		2		3	
	R[1]	L	R	L	R	L	R	L	R	L	R	L
Upper jaws												
Idaho	0	0	0	0	0	0	4	4	1	0	0	0
Montana	0	0	0	0	0	0	4	4	0	0	0	0
Lower jaws												
Idaho	2	1	1	1	0	0	7	9	0	2	0	0
Montana	1	5	2	1	1	0	11	14	0	0	0	0

[1] R = right. L = left.

WEIGHTS OF QUEENSLAND MAMMALS

Finlayson (Trans. Roy. Soc. South Australia, 71: 182–94, 1947) published a list of weights (in the metric system) of some Australian mammals. Weights, in pounds and ounces, of a large number of forms were recorded by Mr. Hobart Van Deusen, a member of the recent Archbold Expedition (1948) to the Cape York Peninsula. A few additional records are taken from a collection lately received from M. J. Roberts, of Cooktown. Those records are now presented in inclusive form.

The weights shown extend from young adults to old adults of both sexes. Numbers which follow in parentheses indicate the number of specimens weighed. The identifications correspond to those given in a forthcoming report on the mammals of the Cape York area (Tate, Bull. Amer. Mus. Nat. Hist., in Press).

Name	*Males*	*Females*
Tachyglossus aculeatus acanthion	2¼—4 lbs. (7)	3½–6 1/16 lbs. (2)
Antechinus flavipes adustus	2–2½ oz. (4)	1¾–2 oz. (4)
Antechinus flavipes godmani	2½–4 oz. (18)	1½–2½ oz. (13)
Sminthopsis aruensis lumholtzi	0.7–1.0 oz. (11)	1½ oz. (1)
Satanellus hallucatus predator	15½—32 oz. (8)	10–18¼ oz. (5)
Perameles nasuta pallidior	2½—4 lbs. (2)	
Isoodon macrourus	3¾ lbs. (1)	1½–2⅛ lbs. (3)
Isoodon obesula	¾—? lbs. (1)	1 lb. 5½ oz. (1)
Petaurus breviceps longicaudatus	3–5 oz. (3)	2½–3½ oz. (5)

Name	*Males*	*Females*
Dactylopsila trivirgata picata	10½–15½ oz. (9)	9½–11½ oz. (3)
Dactylopsila trivirgata infumata		12 oz. (1)
Trichosurus vulpecula eburacensis	4½–5½ lbs. (3)	3½–4½ lbs. (3)
Phalanger maculatus nudicaudatus	6–9 lbs. 4 oz. (6)	6–10¾ lbs. (5)
Phalanger orientalis peninsulae	3 lbs. 10 oz.–5 lbs. (2)	5–5 lbs. 4 oz. (4)
Pseudocheirus peregrinus peregrinus	27½–28 oz. (2)	23½–26 oz. (4)
Dendrolagus bennettianus		15 lbs. (1)
Petrogale inornata godmani		6 lbs. (1)
Thylogale stigmaticus	7–18½ lbs. (2)	4–11½ lbs. (4)
Protemnodon agilis	20–57 lbs. (6)	6–20 lbs. (4)
Macropus canguru	58 lbs.–? (1)	
Macropus robustus erubescens	87–124 lbs. (3)	35 lbs. (1)
Eptesicus pumilus		1/10–¼ oz. (5)
Pipistrellus papuanus		1/10–3/10 oz. (3)
Miniopterus schreibersii blepotis		¼ oz. (3)
Miniopterus australis		3/10 oz. (2)
Nyctophilus bifax		3/10–4/10 oz. (4)
Taphozous australis		¾–1 oz. (15)
Taphozous mixtus		¾ oz. (3)
Hipposideros bicolor albanensis		¼–½ oz. (3)
Hipposideros galeritus cervinus		½–¾ oz. (6)
Hipposideros muscinus semoni		¼–3/10 oz. (6)
Hipposideros diadema reginae		½–2 oz. (13)
Rhinolophus megaphyllus		3/10–¾ oz. (28)
Nyctinomus norfolcensis		¼–½ oz. (4)
Nyctinomus loriae		1/10 oz. (3)
Pteropus conspicillatus		16–30 oz. (5)
Pteropus alecto gouldi		13–20 oz. (4)
Pteropus scapulatus	11½–15 oz. (10)	11¾–14 oz. (9)
Dobsonia moluccensis magna		11–15¼ oz. (5)
Nyctimene robinsoni		1½ oz. (1)
Canis dingo		28 lbs. (1)
Hydromys chrysogaster reginae	18–25 oz. (8)	16–23 oz. (6)
Hydromys chrysogaster beccari		22 oz. (4)
Leggadina delicatula delicatula		¼ oz. (2)
Mesembriomys gouldi rattoides		12½ oz. (1)
Melomys cervinipes eboreus	2–3¼ oz. (7)	1½–2½ oz. (5)
Melomys cervinipes capensis		2–4¾ oz. (25)
Melomys lutillus australius	1⅜–1 3/10 oz. (15+)	¾–1½ oz. (15+)
Uromys caudimaculatus caudimaculatus	20–30 oz. (14)	15–25 oz. (18)
Rattus assimilis coracius	4–6½ oz. (15+)	3–5 oz. (15+)
Rattus leucopus	4–7 oz. (25+)	3½–6½ oz. (25+)
Rattus gestri apex	5–8 oz. (9)	3½–6 oz. (12)
Rattus gestri conatus	4½–6 oz. (2)	2¾–5½ oz. (4)

G. H. H. Tate, *American Museum of Natural History, New York 24, N. Y.* *Received February 28, 1951.*

REVIEWS

Raven, Henry Cushier. THE ANATOMY OF THE GORILLA. The Studies of Henry Cushier Raven and Contributions by William B. Atkinson, Herbert Elftman, John Eric Hill, Adolph H. Schultz, William L. Strauss, Jr., and S. L. Washburn. Arranged and Edited by William King Gregory. Columbia University Press, New York, pp. viii, 1–259, pls. 1–116, 11 tables, 40 figures in text. Price, $15.00.

This book is published as a collaborative work of the American Museum of Natural History and Columbia University, in honor of Henry Cushier Raven, the late Curator of Comparative Anatomy at the American Museum of Natural History. It is not only a very proper memorial to him, but constitutes also a major contribution to the knowledge of primate anatomy.

The publication is divided into five parts. Part I consists of a short biography of Raven, recollections and remarks of appreciation by many friends and colleagues, and a list of his scientific publications. One can hardly fail, while reading this section, to be impressed by the zeal and perseverance shown by Raven during many periods of hardship and ill health as well as by the appreciation and respect which he engendered among his associates.

Part II, entitled "The Regional Anatomy of the Gorilla," comprises the main body of the publication and consists of Raven's original notes, supplemented by remarks by John Eric Hill. After Raven's death, in 1944, Hill undertook to bring to completion those parts of the work which were most nearly finished. This task was interrupted in 1947 by Hill's untimely death. By this time, however, Hill had made many original observations from his own dissections, and the present descriptions of the regional anatomy of the gorilla are made up of Raven's original notes, with Hill's observations inserted, in brackets, in the appropriate places. This section is illustrated in detail by many plates and figures. Most of these are extremely well done and convey an excellent impression of the anatomical details of the particular regions shown. It is unfortunate that a few of the figures appear to be rather hastily done, and detract somewhat from the general high level of quality set by the remainder. Four fold-in plates, showing the extensor and flexor aspects of the extremities at natural size are very well executed, but their size is such that they certainly will be easily torn from the binding. It would appear that these could have been shown at a reduced size without this danger and with little or no loss of usefulness.

Although this section gives an excellent account of the general anatomy, there are many places where too little detail is given to make the description useful from a comparative viewpoint. Particularly disappointing is the absence of descriptive material on the osteology of the gorilla. To criticize the work on this basis would, of course, be unfair, as it is admittedly a report of unfinished investigations. Furthermore, much of the detail which is lacking in the text may be seen in the accompanying plates.

The remaining three parts of this work consist of treatises on portions of the anatomy of the gorilla not covered in Part II, contributed by several of Raven's colleagues. Part III comprises a description of the thoracic viscera by S. L. Washburn, remarks on the abdominal viscera by Herbert Elftman and William B. Atkinson, and on the female reproductive system by William B. Atkinson and Herbert Elftman. These three sections are rather brief and considerably lacking in detail. The descriptions of several organs are so brief and so general as to be useless as a basis for comparison. The authors do, however, give numerous citations to previous publications on the anatomy of these regions of the gorilla.

In Part IV, "The Microscopic Anatomy of the Skin of the Gorilla," William L. Strauss, Jr., gives an excellent paper. Samples taken from ten different areas are described, and numerous comparative remarks are included.

Part V, "Morphological Observations on Gorillas," by Adolph H. Schultz, presents a varied collection of data which, in the author's words, ". . . is intended to fill a few of the many remaining gaps in our morphological knowledge of the gorilla." These data have to do principally with age and growth changes in the gorilla, and since they are taken from a relatively large number of specimens, this section is one of the most valuable parts of the work.

This volume, in general, is an excellent contribution in the field of anatomy, and while it may fall somewhat short of becoming ". . . a standard tool of anatomy departments in medical schools throughout the world," as the publishers suggest, it certainly will find great use as an atlas and as a basis for additional, more detailed descriptive and comparative studies of primate anatomy.—GEORGE C. RINKER.

Roe, Frank Gilbert. THE NORTH AMERICAN BUFFALO: A CRITICAL STUDY OF THE SPECIES IN ITS WILD STATE. University of Toronto Press. Pp. viii + 957. 1951. Price, $12.00.

This book, of primary interest to naturalists (and incidentally to students of the American Indian) and zoologists, is written by someone who can claim to be neither, for its author is an historian. Member of several historical societies, and Fellow of the American Geographical Society, his name will probably be unknown to biologists in general; as he expresses it himself (p. 679): ". . . in my own ignorance of biology, I have steadfastly refrained from intrusion into that sphere. Where I have ventured to criticize biologists or zoologists it has been for their pronouncements as historians." This may sound discouraging for the prospects of the most comprehensive book on the American bison yet written, but actually turns out to be an unusual asset for Roe approaches his subject with the mentality of a critic who has no axe to grind and can therefore look impartially at the writings of those who have posed as authorities. It is interesting, for instance, to see the universally quoted Hornaday (1887, *The Extermination of the American Bison*) critically examined by an independent judge in light of the statements of other authors from many of whom Hornaday derived much of his material. Both men were historians, but where Hornaday had a certain zoological bias, necessarily absent in Roe, he also wrote as a contemporary of the last of the bison, holding certain currently accepted views that were not always right. Roe, writing 70 years later, escapes these possible sources of prejudice and enjoys, in addition, the perspective of time. His method is to weigh viewpoint against viewpoint, author against author, and, in the light of the evidence, which he quotes freely and in detail, to try and determine the validity of each point. This inevitably demands unlimited conversance with the literature—that Roe has achieved this goal and made himself a master of his topic is self-evident on the most cursory perusal of his pages.

With reference to the scheme of his book, Roe says (p. 10) "I laid down for my own guidance three fundamental principles. These were: (1) the insertion wherever practicable of any witness's testimony in his own words; (2) the inclusion of as many contributions as possible on any given topic, particularly where they tended to combat some existing but dubiously supported belief; (3) the rigid and accurate documentation of all statements or evidence of any character. I have earnestly striven throughout to observe these conditions, as I believe that in no other way can a reliable historical account of the buffalo be written." Or again (p. 671) "The object of this essay has been not so much to suggest conclusions as to present facts." It is, however, inevitable that general conclusions would have to be drawn and a short final chapter (XXII) summarizes them.

Roe points out (p. 10) that even now not all the material written on the bison is available to students, referring especially to the archives of the Hudson's Bay Company, the publication of which is yet awaited. That he appears not to have missed much of whatever else is extant is evidenced in his bibliography which includes some 400 authors and titles. Documentation of his references and quotations is extremely thorough, resulting in approximately 3,000 footnotes many of which are themselves annotated and generously cross-referenced. In addition to the text proper, the book concludes with 34 appendices of relevant material which would have disrupted the general thread of the main work and is here collected into separate sections. Since Indians were formerly so directly dependent on the bison, it is inevitable that they should recur with great frequency throughout the text; fourteen of the appendices are devoted entirely to various aspects of the Indian question.

The appendices are mines of information. Among those of particular value to students of bison lore are included titles such as these: Buffalo synonymy (incorporating both European and Indian names); Early buffalo domestication; Albinism in buffalo; Estimates of Indian populations subsisting wholly or partly on buffalo; Buffalo place-names; Buffalo

and disease; Buffalo in the Rocky Mountain passes; Buffalo hide, meat, and bone traffic; etc. In fact one does not fully grasp the tremendous labour (about 30 years of assiduous combing of every source of information from standard works and historical and scientific journals to newspaper and magazine articles) that has gone into this volume until one reads the appendices. They include more than 200 pages, and are in themselves a storehouse of information without parallel in existing literature.

There are indexes, and indexes, to books. Many of them are as aggravating as they are helpful. One naturally turns to this one in an effort to evaluate the methods of the author. As a matter of curiosity I put it to frequent test while reading the text. *Migrations*, for instance, might well turn out to be a mere list of page numbers, but one finds instead subheadings such as these: Borrodaile on; causes examined; character and route of; contradictory evidence; etc., to the tune of 15 sub-titles. Of the 7 columns of index on *Indian tribes*, simplicity and lucidity of treatment make it possible to find any reference in the volume without effort. No attempt to catch out the author in his 42 pages of index proved successful; one may surely assume that he has just about achieved perfection, a rare enough tribute.

The above points are of importance in assessing the over-all worth of the book since it is obviously impossible to check a couple of thousand references to literature, many items of which one has never heard of and many others of which are rare enough to be virtually inaccessible. The general impression is one of exceptional excellence.

The scope of the book is indicated in the following chapter-headings and sub-titles: I, *Introduction;* II, Early buffalo in *North America;* III, *North American variants of the buffalo and their geographical distribution*. These two chapters deal with the historical aspects of various disputes on ancestry and taxonomy and contain much of interest. IV, *Climates and topography of the buffalo habitat:* discussion of physiography and geography, and discrepancies of opinion in the matters of migration and distribution. V, *The buffalo year:* a discussion of debatable views on the life-cycle. VI, *Some buffalo characteristics:* this chapter reviews such matter as reputed intelligence, fierceness, choice of trails, etc. VII, *Agencies destructive to buffalo, other than man, pt. I:* VIII, *Ditto, pt. II:* these are two of the most informative chapters in the book, dealing with the annual toll taken by predators, fire, water, ice, and snow. Roe concludes, and no doubt correctly, that although these agents destroyed thousands of bison under the right circumstances, they were not instrumental in its disappearance. IX, *European discovery of the buffalo:* an historical review which should evidently have been called "European discovery of the *American* buffalo." X and XI deal with the distribution of buffalo on the settled lands of North America, XII with the remoter portions of Canada. The last includes a lengthy discussion of plains and wood bison distribution.

The next six chapters cope with buffalo numbers under the following sub-headings: General references from the earliest times; The Red River Hunt (1831–46); Destruction of the southern herd (1871–4); of the northern herd in U. S. (1882–2); final extermination in Western Canada (*circa* 1889, excluding the wood bison); some suggestions towards the total aggregate. These chapters abound in historical interest. The author accepts Seton's estimate of primitive numbers at possibly 60,000,000, in view of the available evidence and Seton's methods of deduction, as also his further belief that by 1800 they were probably already reduced to 40,000,000. Approximately 80 years later the last wild buffalo had been either captured or destroyed. This provides some basis for calculating the final rate of extermination, but Roe produces all the evidence procurable in the matter of recorded figures of marketed tongues and robes, skeletons shipped by railway companies, etc., and points out the unreliability of many of the statements found in the literature. Personally, I find his own mathematical calculations somewhat involved and regret that this section does not conclude with a summary of dates, events, and probable diminution in numbers of, say, the final 50 years of bison existence. This criticism, as a matter of fact, can be applied to other sections of the book. Since Roe states explicitly that his purpose is to provide information, not opinion, this procedure is excusable, but nevertheless regrettable, since summaries

would enormously facilitate easy reference to the main facts recorded in the bodies of the various chapters. A useful alternative would be a brief table of contents at the head of each chapter.

Chapter XIX deals with one of what Roe elsewhere terms "the two cardinal buffalo theories" (a) "*The 'regular' migration*" (the topic of the present chapter); (b) The buffalo origin of our roads. In chapter XIX he concludes that there was no such thing as a *regular* migration except in the minds of peddlers of an attractive hypothesis. (In his appendix F, entitled "Caribou," he reviews the similar case of the barrenland Caribou, and comes to the same conclusion regarding it) (b) *The buffalo origin of our roads*, only briefly dealt with earlier in the book since it is to be treated *in extenso* in a separate work and has already been the subject of several short papers by our author, is also considered highly improbable.

Chapter XX, "*Irregular migrations*," discussed with reference to the entire bison range, are accepted in the sense of unorganized wanderings basically unpredictable as annual events.

XXI, *Influence of the buffalo environment upon Indian mentality*. This is the longest chapter of the book and deals with certain aspects of the oldest and most important predator (till the Indian's white rival turned up) of the buffalo—the Indian. As with everything else, Roe weighs the pros and cons of the charges of profligate slaughter made against the Indians by their white contemporaries and concludes that although there was some justification—easy money would naturally appeal to Indians as well as to whites, given the chance—the accusation was on the whole unwarranted for the Indians, left to themselves, were not wasteful of the basic source of their own livelihood. He also points out the unhappy thought that the unbelievable wastage perpetrated by the white profiteers of the buffalo "industry" had the blessing both of politics and the army as a potent agent in compelling the recalcitrant Indians ultimately to come to heel.

The final chapter, as already noted, is a brief summary of the author's over-all conclusions.

I have referred above to the omission of chapter-summaries in Roe's History of the Bison, and expressed regrets. There is another omission that is more unfortunate—not a single map is provided. This is, perhaps, the only serious criticism that can be levelled against Roe's great work, although some of his arguments strike one as being possibly unnecessarily extenuated. A book that deals with an entire continent, and is loaded with geographical references, is surely incomplete without maps. It is difficult to see how this oversight occurred, but it can fortunately be easily remedied in any future edition to which, I think, one can look forward before the lapse of many years, for the volume is quite indispensable to any serious student of either buffalo or Indian. As unquestionably the most nearly complete work of reference on the biology of the bison yet conceived (with the unique distinction of having been written by an author who is *not* a biologist), it should at least be in every public library on the continent.

A final word about the author himself. Roe came to southern Alberta as a youngster, in 1894, with his parents. Here he had to "do the chores" and work for a living on a homestead; all formal education inevitably ceased. From then on he was left on his own to pick up whatever he might. Having the type of mentality he has, he soon made himself master of unusually good English and, subsequently, of the bison literature of the continent which was to culminate in the comprehensive volume now under review. On the Canadian prairies, once the home of the teeming bison, Roe spent fifteen years before becoming a railway man, later to be a locomotive engineer and to see for himself vast expanses of the former bison terrain. This gave him a very useful background to his reading, the influence of which makes itself apparent from time to time in his pages. Before this review appears in print, Frank Roe will have been awarded an honorary LL.D. degree by the University of Alberta.

The format and typography of the volume are above criticism. Except for a few minor typographical errors, the rest is an exemplary sample of the printer's art.—Wm. Rowan.

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(Conducted by G. S. Miller, Jr., Emma Charters, D. H. Johnson, and R. H. Manville)
[Reprints of this section may be purchased from the Corresponding Secretary]

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COMMENT AND NEWS

RESEARCH FUNDS AVAILABLE

The National Science Foundation, 2144 California Street, N. W., Washington 25, D. C., announces that it has earmarked approximately $1,500,000 for the current fiscal year for the support of basic scientific research. Anyone interested in making application for funds, and whose institution does not have the details, may write directly to the above address for their "Guide for the Submission of Research Proposals."

ZOOLOGICAL RECORD (MAMMALIA)

Many of our readers may not know that it is possible to purchase the section on Mammalia, from the Zoological Record, separately. Vol. 85, containing references to the publications of 1948, is published and may be obtained for 5s. plus 4d. postage from the Secretary, Zoological Society of London, Regent's Park, London, N. W. 8, England. Volume 86 was scheduled to appear in December, 1951, and Volume 87 should be published by midsummer, 1952. The Zoological Society is making an attempt to revert to pre-war practice and bring out each volume less than twelve months after the end of the year to which it refers.

PUBLICATIONS AVAILABLE

The Linnaean Society of New York is clearing out its back stock of publications at reduced prices. The proceeds will be used to pay for further publications. Vols. I and II of the Transactions (Merriam's account of the mammals of the Adirondacks, with notes on the fisher, etc.), both for $2.00. Proc., no. 7 (Gundlach on Cuban Mammals), 50 cents. Papers on mammals of Westchester County, New York, and on mammals of Long Island (Proc., 1902), 50 cents.

If interested in any of the above items, write to *Dean Amadon, American Museum of Natural History, New York.*

ALLEN'S CHECKLIST OF AFRICAN MAMMALS

In response to repeated inquiries, the M. C. Z. plans to reprint Glover M. Allen's Checklist of African Mammals if the demand is sufficient. Copies will sell at ten dollars each. Will those who are interested please communicate at once with *Barbara Lawrence, Mus. Comp. Zool., Harvard College, Cambridge, Mass.*

MUSEUM PICTORIAL, A NEW PUBLICATION

The Denver Museum of Natural History has started a new series of publications, MUSEUM PICTORIAL. The first issue, "Nature Photography with Miniature Cameras" by Alfred M. Bailey, contains many of Mr. Bailey's excellent photographs. An additional feature is the running account by the author of how he obtained the photographs, and interesting background material for the regions where the pictures were made. The format is pleasing and the reproductions are superbly done.

DATE OF ISSUE OF PREVIOUS NUMBER

Journal of Mammalogy, Vol. 32, No. 4, was mailed **November 19, 1951**

ANNUAL MEETING

The thirty-second annual meeting promises to be one of the best that the Society has had so far. The place, *Charleston, South Carolina.* The date, *April 14–18, 1952.* Headquarters will be at the Chapel, College of Charleston. There will be a dinner for the Officers and Directors at 6:00 P.M., Monday, 14 April. The meeting of the Board of Directors will follow at 8:00 P.M. of the same day. On Tuesday, 15 April, registration will start at 8:30 A.M., and the regular sessions will begin at 9:00 A.M. There will be a tea for the wives at 5:00 P.M., and an informal get-together at 8:00 P.M. On Wednesday, 16 April, there will be regular sessions, the annual business meeting at 10:30 A.M., and the annual banquet at 7:00 P.M. Thursday, 17 April, will see the termination of the regular sessions, the final business meeting, and a visit to Charleston's Famous Gardens. Friday, 18 April, is reserved for field trips to spots of interest nearby.

The Local Committee, with R. H. Coleman as Chairman, is going all out to make this an enjoyable and educational meeting. We urge all to set aside April 14 to 18 for this 1952 convention of the American Society of Mammalogists.

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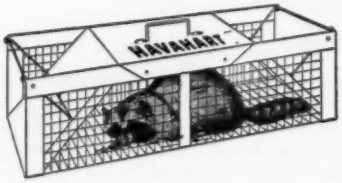

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